THE JULY SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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THE SCIENTIFIC MONTHLY

JULY, 1933

RESEARCH IN THE BUREAU OF PLANT INDUSTRY

By Dr. WM. A. TAYLOR

CHIEF OF THE BUREAU

SEVERAL times during the last few years the question has been asked, "Why not discontinue work upon the control of plant diseases and allow the ravages of these diseases to at least partially solve the problem of overproduction?"

The losses from plant diseases unfortunately fall unequally upon the producing public. An epidemic will affect only certain irregular areas, causing heavy damage to individuals farming there, the curtailment in production perhaps temporarily benefitting other regions. From the standpoint of the nation such irregularity of production is objectionable, because it not only injures or bankrupts certain groups of people but it increases the average cost of production for the entire country; it is not a cure for overproduction. Plant disease epidemics at best can give only temporary benefit in reducing the total crop and generally result in national injury due to lowered efficiency of production, lowered quality of product, and eventual increased acreage of crops affected. For with abandonment of disease control activities overproduction may occur and, unfortunately, may become more unpredictable than at present. Better adjustment of production to demand obviously must rest upon a steady basis of production, but it is in problems of quality rather than in more general problems of total yield that the importance of stabilized production from year to year is realized as a fundamental economic advantage for both the producer and the consumer. The importance of the utilization of better varieties of crop plants is one of the factors in reducing the costs of crop production and at the same time gaining in quality of the crop produced. Obviously the most dependable and therefore the most predictable results in both yield and quality can be secured by the simultaneous application of improved cultural and disease control practises and the utilization of improved crop varieties.

Investigations in plant physiology, genetics and plant pathology provide the necessary groundwork for the breeding of crops immune or highly resistant to formerly destructive plant diseases and for the development of cultural practises, spraying materials, and other practical methods for controlling losses from disease. The control of plant diseases through the breeding of resistant varieties is less spectacular than some other agricultural achievements, but the results of recent years establish this as the most economical and most effective

method of avoiding increasing losses in regions where climatic and other factors require large acreages of the same crops year after year. Agricultural research has not eliminated disease epidemics in crop production but it has reduced their severity.

From the outset the Bureau of Plant Industry has devoted a large part of its activities to the identification and study of destructive plant diseases and, although there is clearly great improvement in the production of many crops resulting from methods of disease control established by the Bureau and cooperating state agencies, in most cases it is difficult to estimate this benefit in financial terms. A few items which can be approximated with a reasonable degree of accuracy are:

Savings from Disease Control

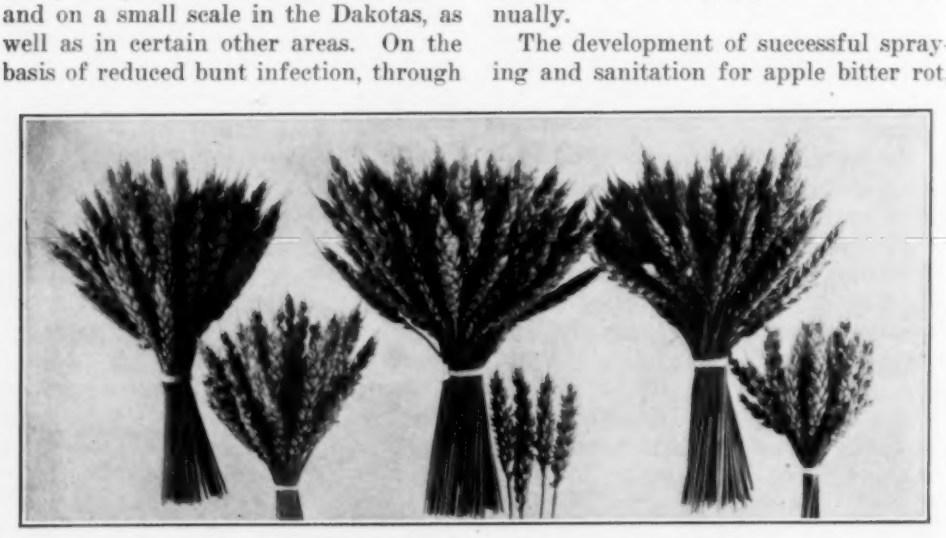
For the prevention of bunt disease of wheat, the copper-carbonate treatment applied to seed wheat has been extensively adopted in Minnesota, Montana, and on a small scale in the Dakotas, as well as in certain other areas. On the basis of reduced bunt infection, through improvement in seed disinfection methods ordinarily used, the net gain amounts to more than 5,000,000 bushels annually.

The discovery that heat canker of flax can be largely controlled by earlier seeding has resulted in a much wider application of this practise. On the average, better yields are obtained from early seeding, so the value resulting from this discovery is much greater than the direct one resulting from the control of the canker itself. It is conservative to estimate a gain of 500,000 bushels annually from earlier seeding.

In the prevention of peach-leaf curl and California peach blight through methods of spraying discovered by the Bureau an annual saving of about 2,000,000 bushels of peaches has been accomplished.

The development of self-boiled lime-sulphur spray gave growers a practicable control of brown rot and scab of peaches, and to growers of stone fruits this has saved 12,000,000 bushels annually.

The development of successful spraying and sanitation for apple bitter rot,



WHEAT SEED TREATMENT FOR SMUT CONTROL

From left to right: 50% healthy; 50% smutted (untreated seed); 96% healthy; 4% smutted (seed treated with copper carbonate); 72% healthy; 28% smutted (seed treated with formaldehyde).

blotch, scab and scald, and the development of the oiled wraps for apples have approximated annual gains or savings of 20,000,000 bushels of merchantable fruit.

Improved Handling Methods

Previous to the 1909 orange crop the losses sustained by the California orange growers from the rotting of oranges in transit ranged from 8 to 20 per cent. of the total shipment, averaging around 12 per cent., and these losses seemed to be steadily increasing. Our specialists after laboratory and field investigations showed that by careful handling it was feasible to reduce the losses from rot in transit to less than 2 per cent. In addition to the actual increase in quantity of sound oranges delivered in the markets, the eating quality and therefore unit value of the crop has been enormously increased by the improved methods of handling and more efficient refrigeration practise and equipment, yet costs have been reduced. During the past year we concluded a series of demonstrations showing that oranges may be shipped from California to eastern markets by pre-cooling the fruit and loading in pre-iced cars which may be again refilled with ice by the shipper before moving, after which only one reicing in transit is needed instead of ten to twelve as provided under the standard refrigeration previously employed. This one improvement alone will save upward of $30.00 a car, or will save orange growers a half million dollars or more a year.

Eradication Campaigns

Sometimes the attack upon a plant disease appears to be more practicable through a campaign of eradication directed toward either the disease itself or some plant capable of transmitting or accentuating its ravages, rather than through spraying or similar control practises. Four extensive direct service campaigns in cooperation with the states concerned are under way for controlling the citrus canker disease in the Southeast, the white pine blister rust in both the eastern and western white pine areas, the barberry eradication campaign for control of black-stem rust of wheat in the spring wheat states, and the phony peach disease of the southern peach-growing states.

Citrus canker. The campaign for the eradication of citrus canker, a bacterial disease of citrus fruits and trees, was undertaken in 1915, in cooperation with the Gulf States, namely, Florida, Alabama, Louisiana, Mississippi and Texas. The disease has now been practically eliminated from the greater portion of the commercial citrus-growing region, and, with the exception of scattering infections in Louisiana and Texas, the disease appears to have been eradicated. There is no question but that the important citrus industry of the Gulf States has been saved by this intensive campaign.

White-pine blister rust. Only a few years ago it was doubtful whether the continued growing of the white pines in the Northeastern states was economically possible because of the destructiveness of the white-pine blister rust, a disease that was introduced from Europe on nursery stock. It spreads to the pines only after an intermediate development on Ribes (currant and gooseberry plants). Repeated experiments over a wide range of forest conditions in this country showed conclusively that these bushes could be successfully suppressed and the pines thereby protected on any area where the pine values justified the cost. White-pine areas aggregating more than 8,000,000 acres have been effectively protected from blister rust in New England and New York at an average cost of 21 cents an acre. These areas should be reworked system-

atically at about 5-year intervals, but the cost for these follow-up operations will be less than that of the initial work. The labor has been furnished by pine owners and local agencies, and supervision and direction have been supplied jointly by the Bureau and the affected states. These results, accomplished by systematic work throughout the region, assure the growing of a revenue-producing crop of white pine on millions of acres of nonagricultural land that would otherwise be a liability.

Climatic conditions in 1931 promoted the extensive spread of the white-pine

INFECTED BY BLISTER RUST

GROUP OF LARGE WHITE PINES. SINGLE BAND: TREES WITH TRUNK CANKERS. DOUBLE BAND: TREES KILLED. CROSS: TREES WITH BRANCH CANKERS ONLY.

blister rust in the eastern part of the United States. From the generally infested northeastern region the disease spread into the bordering states of Maryland, Virginia, West Virginia and Ohio. In the Lake States region it was found in several new places, including one in Iowa. In the commercial areas of western white pine in northern Idaho, 45 additional centers of pine infection were found, showing the rust to be firmly established in that region. The disease was again found on Ribes in southwestern Oregon within 40 miles of the California line and within the range of valuable forests of sugar pine which are known to be susceptible. It now appears certain that the rust will reach the main sugar-pine belt of California.

The problem of controlling the rust in the western part of the United States is comparatively new because of the more recent discovery and spread of the disease in that part of the country. Forest conditions differ entirely from those in the East, where the large-scale application of effective control measures is under way, and require new methods for destroying Ribes. Good progress has been made in developing and applying these methods in cooperation with the affected states and local agencies.

Barberry eradication. The campaign to eradicate the common barberry, for the purpose of reducing stem-rust losses of small grains, was undertaken in 1917 with Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin and Wyoming. It is evident that barberry eradication is a material aid in the solution of the stem-rust problem. A single infected barberry bush has been known to cause a local loss to wheat growers, in one township in one year, of more than 10,000 bushels of grain. In the eastern winter-wheat producing states of the eradication area stem rust of wheat is controlled as soon as the barberries are eradicated from a locality. Since 1918 more than 18,000,000 rust-spreading barberry bushes have been destroyed in the 13 more important small grain-growing states. Of these 18,000,000 bushes some were planted for orna-

mental and hedge purposes but a larger percentage grew from seed scattered by birds. With the eradication of these bushes there has been a steady reduction in the number and severity of stem rust epidemics. The following table shows that losses from stem-rust decrease as progress is made in barberry eradication:

LOSSES FROM STEM RUST DECREASE AS PROGRESS IS MADE IN BARBERRY ERADICATION

Wheat losses resulting from black stem rust in 13 northern states by 5-year periods.

1916–20	285,000,000 bu.
Average annual loss	57,000,000 "
1921–25	85,000,000 "
Average annual loss	17,000,000 "
1926–30	45,000,000 "
Average annual loss	9,000,000 "

Rust-spreading barberry bushes destroyed since beginning of stem-rust control program.

1916–20	4,000,000 bu.
1916–25	12,000,000 "
1916–30	18,000,000 "

Had there been no organized effort to free the northern small grain-producing states from barberry these bushes would have continued spreading at a steadily increasing rate resulting in more numerous and more destructive epidemics of the disease.

Phony peach eradication. In the cooperative campaign for the eradication of the phony peach disease 40,538,560 trees have been inspected from 1929 to 1932 inclusive and 449,754 infected trees were found, as follows:

Alabama	8,908	Missouri	17
Arkansas	568	North Carolina	50
Florida	323	Oklahoma	3
Georgia	437,038	South Carolina	196
Illinois	14	Tennessee	59
Louisiana	777	Texas	633
Mississippi	1,168		

FIELD CREW

ERADICATING WILD CURRANTS TO PROTECT WHITE PINE FORESTS FROM BLISTER RUST DISEASE.

In the inspection carried on in 1930 and 1931 no diseased trees were found in Connecticut, Delaware, Indiana, Kansas, Kentucky, Maryland, Michigan, New Jersey, New York, Ohio, Pennsylvania, Virginia and West Virginia. At the present time, so far as is known, the disease does not occur north of North

WHITE PINE BLISTER RUST

A DESTRUCTIVE DISEASE OF WHITE PINES. INSPECTOR HAS ONE HAND AT THE TOP AND ONE AT THE BOTTOM OF THE BADLY CANKERED AREA.

IMPORTANT VARIETIES OF COMMON WHEAT

From left to right: Marquis; Power Fife; Haynes Bluestem; Preston. (About one eighth natural size.)

Carolina and Tennessee, except as indicated. Most of the outlying infections, as in North Carolina, Tennessee, Illinois, Oklahoma and Missouri, are isolated ones, indicating that the disease was introduced into these states through the movement of infected nursery stock.

SELECTIONS OF DURUM WHEAT HEADS

From left to right: Kubanka; Arnautka; D–5; Peliss. (About one seventh natural size.)

In Georgia, where the disease is most serious and where the most active work has been carried on, as a result of the eradication campaign the number of infections has been materially reduced. In the heavily infested territory in Georgia, where whole orchards of from 25,000 to 50,000 trees were removed because of the phony disease, the growers are watching the campaign very closely, basing their future actions on the results achieved in eradication or at least controlling the disease.

Plant Breeding to Subdue Disease

The potato is the leading vegetable of the United States. More than a decade ago the so-called "running out" of good varieties due to the potato diseases now referred to as mosaic, leafroll, spindle tuber and streak had become the greatest handicap to potato growing and to crop improvement for producers throughout the country. These virus diseases, carried from year to year in the tubers of the diseased plants and more widely spread in the field by aphids or plant lice, had led to the belief that potato varieties were all subject to weakening or "running out" after a few years' growth in a region and there was therefore a constant search for new varieties of potatoes and simultaneous discarding of some of the most important productive varieties. Our researches not only showed that the "running out" was due to an obscure group of infectious diseases but also established the practicability of commercial elimination of these virus diseases from potato seed stocks and demonstrated the value to the grower of market potatoes of insisting upon seed potatoes known to be free of these diseases. From this work has come the modern supervision by state officers of potatoes grown for seed and the development of a wide-spread interest in the use of cer-

tified seed potatoes for market production. It is estimated that the potato growers of the country have been saved millions of dollars annually through the use of the almost completely disease-free certified seed potatoes. Disease control and crop improvement can go hand in hand for many reasons, and among them plant breeding deserves especial mention.

Another virus disease affecting sugar beets in the western areas of production known as the curly-top disease of sugar beets and disseminated by the beet leaf-hopper has resulted in very heavy losses both to beet growers and to sugar companies for many years. Researches relating to this problem are approaching a commercial success through the development of strains of sugar beets of satisfactory sugar yield and cultural qualities and with the added advantage of partial immunity or tolerance toward the curly-top disease. Beet strains recently developed in test experiments have produced satisfactory yields of beets or sugar per acre under conditions of beet leaf-hopper and curly-top infestation that were sufficiently severe to destroy crops of sugar-beet strains ordinarily used. At the present time increase in seed supplies is being arranged for and within a comparatively few years the losses to the western sugar industry from curly-top probably will be eliminated.

Occasionally by rare good fortune it occurs that the work of plant breeders in regions where research work on the crop has been longer under way is unexpectedly found to meet a critical need. Thus, when the mosaic disease of sugar-cane threatened the very existence of the sugar industry of our Gulf States a few years ago, it was rather promptly found that certain cane varieties, bred in and for the tropical sugar industry of Java, were both fairly well suited to the conditions of our Louisiana sugar belt and satisfactorily resistant to the mosaic diseases. Their availability for the prompt replacement of the disease-susceptible canes made possible the prompt resuscitation of the industry. This is evidenced by the quadrupling of the actual production of sugar in Louisiana between 1926 and 1929. It is recognized, however, that the Javanese varieties of cane do not possess all the characteristics desirable for the perma-

CHINESE ELM, *ULMUS PUMILA*
INTRODUCED INTO THIS COUNTRY BY FRANK N. MEYER. PARTICULARLY ADAPTED TO THE GREAT PLAINS REGION, BOTH AS AN ORNAMENTAL AND A WINDBREAK.

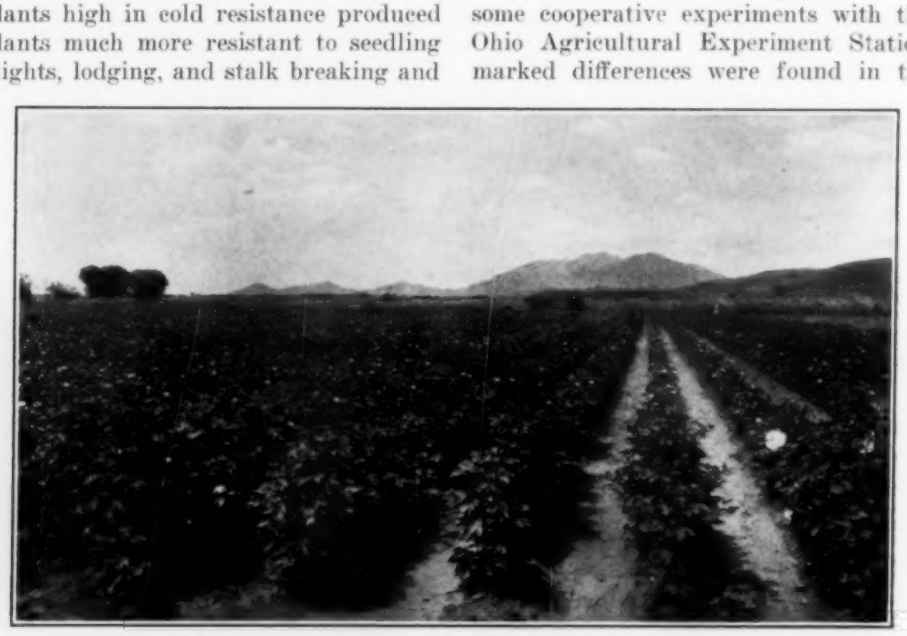
nent maintenance of our cane-sugar industry upon a prosperous basis. Accordingly, an airplane expedition sent by the Department to New Guinea in 1928, with the active cooperation of the industry, has assembled and brought back to this country as breeding stock more than 100 primitive varieties and strains of cane from which it is hoped through combination with existing varie-

ties to produce better sorts for our exacting conditions.

Breeding and adaptation of varieties. Experiments conducted in cooperation with Funk Bros. Seed Co. and the Illinois Agricultural Experiment Station, using a portable field refrigeration chamber in which temperatures can be automatically controlled, have shown that certain inbred strains of corn and their hybrids are highly sensitive to temperatures above the freezing-point as they approach maturity. Other strains and hybrids are uninjured by such temperatures. Some strains are able to resist temperatures even slightly below the freezing-point. These experiments explain field observations of the behavior of these varieties. It also has been found that corn tissues injured by frost are unusually susceptible to such fungi as *Diplodia zeae* and *Basisporium gallarum*. Seed matured on the corn plants high in cold resistance produced plants much more resistant to seedling blights, lodging, and stalk breaking and thus establish improvements in seed corn selection.

Better Varieties

Extensive corn-breeding investigations at several cooperating experiment stations have given impressive evidence of the value of the new methods being used. Many strains developed in the various cooperative breeding programs yielded from 10 to 50 per cent. more than the best local varieties in experiments in Virginia, South Carolina, Kansas, Nebraska, Iowa and Ohio. Four strains, which were developed in the breeding program carried on cooperatively with the Iowa Agricultural Experiment Station and entered in the Iowa yield test, produced 10, 9.7 and 7.8 bushels per acre more than the best of the open-pollinated varieties in the northern, north-central, south-central and southern sections, respectively. In some cooperative experiments with the Ohio Agricultural Experiment Station marked differences were found in the



FIELD OF EGYPTIAN COTTON OF THE PIMA VARIETY

GROWING IN THE SALT RIVER VALLEY OF ARIZONA. THIS COTTON PRODUCES A STRONG FIBER 1¼ TO 1⅜ INCHES LONG, USED IN THE MANUFACTURE OF FABRICS COMBINING FINE QUALITY AND GREAT STRENGTH.

STUDYING THE COMPARATIVE BEHAVIOR OF FOREIGN WHEAT VARIETIES IN NORTH DAKOTA.

ability of strains of corn to respond to fertilizer applications. Two crosses were grown both without fertilizer and with an application of 16 tons of manure and 800 pounds of commercial fertilizer per acre. The first yielded 36.3 bushels without and 49.6 bushels with fertilizer, a difference of only 13.3 bushels, whereas the second yielded 43.9 bushels without and 70.7 bushels with fertilizer, a difference of 26.8 bushels, or twice the increase of the first.

Newturk is an awnless, hard, red winter wheat developed in the Bureau's breeding program. It has been widely tested for adaptation in the western United States. In cooperation tests in Montana it has been found equal to Kharkof and Karmont, standard hard red winter varieties, in yield, winter hardiness, and quality. There is a continuing demand for an awnless winter wheat in the western area. This variety meets that need and has been distributed for commercial growing in Montana.

In 1930 the varieties Tenmarq, bred in cooperative experiment at the Kansas station, Oro, selected in cooperative experiments at the Moro, Ore., branch station, and a selection from Crimean Cheyenne (Nebraska No. 50), from the Nebraska station, proved to be the most promising new varieties in the southern and central United States.

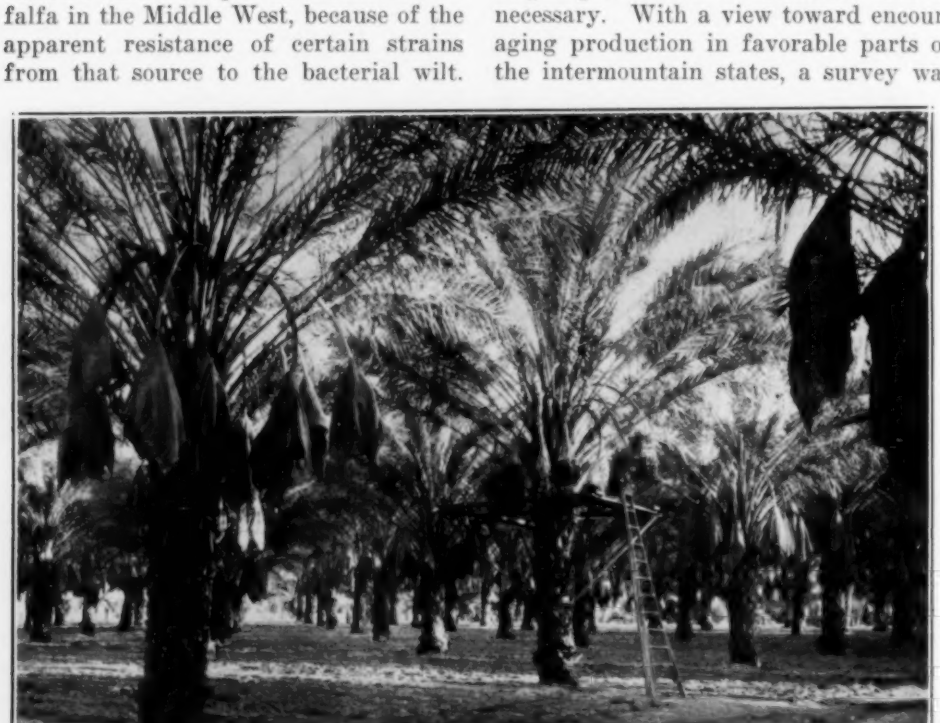
In the north-central hard red spring wheat area, the breeding program is largely centered around hybrids between the Hope variety and the best commercial varieties, Ceres, Marquis and Reliance. Hope, in addition to its high resistance to stem rust, is also highly resistant to stinking smut. Certain selections from these crosses have been entirely free from rust under all conditions where tested, and in addition are resistant to stinking smut. The best of these strains also are high yielding and from such information as is available would seem to be of satisfactory commercial quality.

Regional Adaptability

The demand for information regarding the adaptability of alfalfa seed from various sources has been greater than ever before and has necessitated increased attention to this phase of alfalfa investigations. New tests were therefore started in cooperation with agricultural experiment stations in the East

and in the Corn Belt, and the work was enlarged at stations where work was already under way. The results of the past year's work bear out the previous tests in showing that none of the imported alfalfas are superior to some of our domestic strains for any part of the United States with the possible exception of those districts where bacterial wilt is prevalent. Most of the seed from foreign sources, however, is fairly satisfactory when sown in those limited areas to which the seed is adapted. Argentine alfalfa has given good results in the South, though seldom equaling the best domestic strains in yield. The use of seed from that source in the North ordinarily results in serious losses through winter killing. Recently considerable interest has developed in Turkestan alfalfa in the Middle West, because of the apparent resistance of certain strains from that source to the bacterial wilt. This statement, however, must be accepted with some reserve for the present, for the evidence is by no means complete. The importance of the wilt problem and the observational evidence from old fields warrant a continuance of this line of work, and further studies are under way to determine definitely the resistance of this strain to bacterial wilt.

Since the passage of the seed-staining amendment to the Federal Seed Act, samples representing most of the lots of red clover imported have been subjected to field tests. The records show that the red-clover seed imported into this country during recent years gives results far below those obtained from the use of domestic seed. It is evident that a larger production of domestic seed is necessary. With a view toward encouraging production in favorable parts of the intermountain states, a survey was



DATE PRODUCTION IN SOUTHERN CALIFORNIA

A NEW INDUSTRY FOR THE UNITED STATES. THE BUNCHES OF DATES ARE PROTECTED FROM SHOWERS AND FROM DUST UNTIL PICKING TIME.

made and arrangements completed for trials by 36 selected farmers in 22 counties of 5 states. While favorable conditions of climate and soil were naturally taken into account, the economic factors were also studied and an effort was made to establish trials in sections so far from the railway that the hauling of hay or grain had proved unprofitable. Clover seed having a high unit value can be hauled longer distances. The establishment of a clover-seed growing industry should, therefore, be of benefit to the residents of these intermountain states as well as to the eastern consumer of red-clover seed.

Single-Variety Cotton Communities

As a result of intensive studies of cotton-production problems in the United States by specialists of the Bureau of Plant Industry, superior varieties of cotton have been bred, while others have been discovered and introduced from abroad and developed in this country, including such varieties as Acala, Lone Star, Columbia, Trice, Foster, Express, Durango, Meade and Pima. The Acala cotton, a superior upland variety producing a premium staple, was discovered in 1906 in a remote region of southern Mexico by an expedition sent out by this department. It was introduced, selected and established in cultivation in the United States. It is estimated that the 1925 cotton crop of California and the Mexican Imperial Valley (practically all of the Acala variety) had a value of $27,200,000. For the 7-year period from 1919 to 1925, inclusive, the cotton crop of California, including the Imperial Valley district in Lower California, had a total value of $126,543,000, which was largely the result of planting superior varieties of cotton introduced and developed by the specialists of this bureau. With the exception of a small acreage of the Pima Egyptian cotton in the Salt River Valley of Arizona, practically the entire irrigated cotton area of western Texas, New Mexico, Arizona and California is now producing Acala cotton. The Acala cotton is also being grown on hundreds of thousands of acres in the natural rainfall regions of Texas, Oklahoma and Arkansas.

Continued encouragement has been given by the Bureau to community cooperation in the growing of a single superior variety of cotton as a means of improving quality and establishing uniformity of product and thereby obtaining better prices. The present crisis resulting from overproduction of cotton of inferior quality emphasizes the importance and need of such a plan.

Statistics of recent years from manufacturing countries in Europe show a notably increasing use of cottons from other producing countries and a relative decline in the use of American cotton. The loss of our export market is threatened unless the tendencies to deterioration can be checked. American manufacturers are handicapped by the lack of enough good fiber, and much of the American export product is of a grade that comes into direct competition with the very short staples of India and China. The present production of millions of bales of inferior fiber in the United States is a vast and needless waste of farm labor and resources. With better varieties available, as early and as productive as the very short staples, no agricultural reason exists for planting varieties with less than 1-inch staple in any part of the United States.

A general effort is now being made to establish the production of better qualities of fiber in the United States. Fine fabrics are again in demand as the world recovers from the stress of the war period. Larger quantities of strong and uniform fiber are needed in the automobile industry, and new require-

A GROVE OF WASHINGTON NAVEL ORANGE TREES

A TREMENDOUS INDUSTRY BASED ON A FEW TREES INTRODUCED FROM BRAZIL THROUGH THE FEDERAL GOVERNMENT IN 1871.

ments are being recognized for fabrics of the greatest possible strength in airplanes, balloons, dirigibles and parachutes.

The first practical step for regional improvement in cotton is dependent upon the adequacy of supplies of select seed year after year, and this is feasible only in communities or districts where the farmers unite upon the production of a single variety.

CITRUS IMPROVEMENT BY BUD SELECTION

A striking illustration of benefit to the citrus industry as an outgrowth of research work is that resulting from the bud selection for nursery propagation, based upon tree-performance records. The per-acre production of oranges previous to the inauguration of the improvement of orchards by bud selection was so small that the annual output per acre averaged only about 1 box per tree, and at a tree price of less than $1 per box the income was hardly sufficient to maintain the groves even at the then low cost of labor. With the improvements resulting from bud selection and an equal number of acres in oranges, the per-acre production has very greatly increased, so that the industry during recent years has been fairly remunerative and in some particular groves highly remunerative. The elimination of the nonproductive and nonpaying trees through top-working them with productive strains, and the planting of new orchards the trees of which were propagated from highly productive parent trees, have resulted in a decided increase in total production with a relatively small increase in the total acreage devoted to the industry. It is very difficult to estimate the value which this activity has really contributed to the industry. Like compound interest, it accrues each year with the recurrence of the annual crop, and as the trees grow older and larger and produce more, the effects of the system become more and more apparent both in the harvest and in the total profit of the industry. It is safe to say that several millions of dollars have been contributed to the citrus industry of California as a result of the elimination of nonproductive trees through the principles of fruit improvement by bud selection.

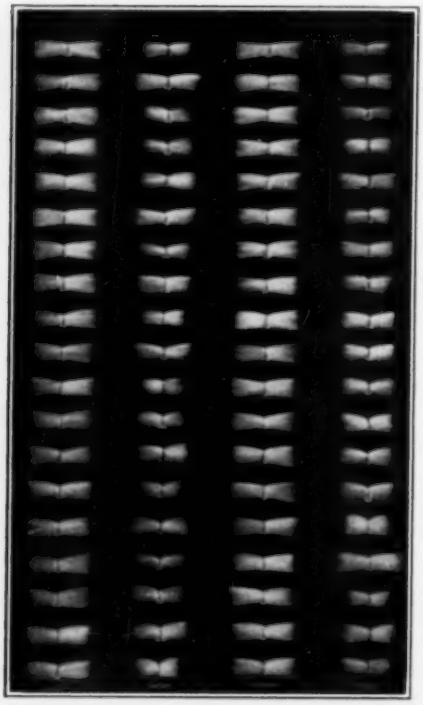
The principles of bud selection, which were first discovered and clearly established in connection with the citrus industry, are found to apply in many lines of deciduous fruit production as well and are more or less applicable to all of the economic plants propagated by budding, grafting, or other vegetative methods. The far-reaching character of these principles will exert constantly increasing benefit on production as time and opportunity afford increasing application to commercial problems.

Introducing Foreign Plant Varieties

Among the first of the major activities of the Bureau was the study of foreign cereals and the selection and introduction of certain important varieties for trial in the United States. The first introduction of a new grain upon a large scale was the establishment of the durum varieties of wheat introduced from Russia, which are adapted to certain severe climates of the United States where the varieties of wheat previously grown were unsuited. As a result durum wheats have added 50,000,000 bushels annually to the wheat crop of the country. Other outstanding examples include hairy Peruvian alfalfa, an important variety in California and Arizona with an annual value of about $5,000,000; the date palm in several varieties, well established in the Southwest; Sudan grass, with an annual crop worth $10,000,000; Barouni olive; the Meyer lemon; the avocado and mango in variety; the dasheen; the jujube; the Quetta nectarine; the Japanese flowering cherries; and a wide range of other field and vegetable crop varieties, fruits, and ornamental shrubs and trees. The soy-bean crop, with an estimated total annual value of nearly $100,000,000, consists of many varieties; the Department has introduced over 5,000 varieties, and selections from these form the basis of the present crop. The Chinese elm, rapidly becoming one of the most widely planted shade and

WAGON LOADS OF SEED COTTON WAITING TURN AT THE COTTON GIN

In a mixed variety community each wagon may represent a different variety. Mixing the seed at the gins is responsible for rapid mongrelizing of varieties, resulting in irregular inferior fiber.



COMBED FIBER ON THE COTTON SEED

FROM SUCCESSIVE PLANTS GROWN FROM SELECTED SEED, COMPARED WITH COMBED FIBER FROM SUCCESSIVE PLANTS GROWN FROM MIXED, GIN-RUN SEED. NOTE THE UNIFORMITY OF FIBER IN THE SELECTED STOCK (FIRST AND THIRD ROWS) AND THE IRREGULARITY OF FIBER IN THE UNSELECTED STOCK (SECOND AND FOURTH ROWS). (ABOUT ONE EIGHTH NATURAL SIZE.)

shelter-belt trees of the Great Plains region, was first introduced from China by an agricultural explorer.

RUBBER

A rubber-producing plant, *Euphorbia intisy*, unusual in its special adaptation to desert conditions, was introduced from southern Madagascar in 1928, and is being propagated and its behavior is being tested at field stations in California and Florida. All of the principal types of tropical rubber trees, including American, African and Asiatic species, have produced vigorous individuals and most of the species have flowered and fruited in Florida. The Hevea or Para rubber tree of Brazil, the principal commercial species grown in the West Indies, flowered and fruited for the first time in Florida during the season of 1931 at the U. S. Plant Introduction Garden, a few miles south of Miami. While commercial production of rubber in the United States under existing conditions is not practicable, in view of the exceptionally wide use of rubber in the United States it is important to be prepared to undertake continental development if any urgent need should occur.

TAPPING A HEVEA RUBBER TREE

IN HAITI, W. I., WHERE TAPPING EXPERIMENTS WERE CONDUCTED BY THE U. S. DEPARTMENT OF AGRICULTURE. YIELDS AND QUALITY OF RUBBER OBTAINED FROM THESE TREES, WHICH ARE GROWING HUNDREDS OF MILES BEYOND THE SUPPOSED NORTHERN LIMIT FOR THIS SPECIES, HAVE BEEN COMPARABLE TO THOSE OBTAINED IN THE LARGE HEVEA PLANTATIONS OF THE ORIENT WHERE PRACTICALLY ALL THE COMMERCIAL SUPPLIES OF RAW RUBBER ARE PRODUCED.

Understanding Varietal Differences Essential for Effective Utilization

The great variety of problems under investigation in the Bureau of Plant Industry renders even a comprehensive summary of its activities impracticable in the space of a short paper, accordingly only a few of the activities that lend themselves to brief description have been summarized in order to indicate the general plan and purpose of the Bureau. Modifications of the plans described are followed in other research activities that range all the way from preparing detailed instructions for the benefit of county agents or others directly interested in applying improved methods of crop production to the more difficult and more time-consuming fundamental researches of genetics, plant physiology and plant pathology, upon which the more practical improvements in crop production are eventually developed. It is these subjects, for example, that established that for many products the older ideas of cold storage are incorrect, and that different products require entirely different treatment for their handling either prior to transportation or while in storage; also determining what varieties of fruit or vegetables are best adapted for canning or freezing and what varieties are more satisfactory to be utilized while in fresh condition.

National progress in agriculture through intelligent appreciation of existing facts and through the development of new ideas directly or indirectly related to crop production and plant growth has been the underlying purpose of the Bureau. Some of its activities have accordingly dealt more with general agricultural efficiency than with crop handling—for example, the organization of farm-management studies, now a branch of the Bureau of Agricultural Economics; the employment of local agricultural advisers of farm demonstration agents, now enlarged into the Smith-Lever extension, States and Federal Government cooperating; studies of rural organization and systems of agricultural marketing, later organized as the Bureau of Markets and now a part of the Bureau of Agricultural Economics; all these began as offices or branches of the Bureau of Plant Industry and developed until their size or relation to other branches of the department rendered their transfer expedient.

In general, the bureau carries on a very considerable portion of its activities in intimate cooperation with the scientific people of the state agricultural experiment stations and serves as a clearing house for the exchange of ideas relating to the problems of crop production between the different members of the state experiment stations and research men of the Department and also between the different crop producing industries and the county agents.

THE WORK OF THE NATIONAL BUREAU OF STANDARDS IN CHEMISTRY AND METALLURGY

By Dr. EDWARD W. WASHBURN

CHIEF CHEMIST, NATIONAL BUREAU OF STANDARDS, U. S. DEPARTMENT OF COMMERCE

CHEMISTRY

THE chemical work of the Bureau of Standards is at present administered under several different divisions, as shown by the following organization chart:

ADMINISTRATIVE ORGANIZATION OF THE CHEMICAL WORK OF THE BUREAU OF STANDARDS

The Division of Chemistry, E. W. Washburn, chief; P. H. Walker, assistant chief.
- (1) Physical chemistry, E. W. Washburn.
- (2) Paints, varnishes and other organic protective coatings, P. H. Walker.
- (3) Detergents, cements and miscellaneous materials, F. W. Smither.
- (4) Organic chemistry, C. E. Waters.
- (5) Metal and ore analysis, standard samples, G. E. F. Lundell.
- (6) Chemical reagents and the platinum metals, E. Wichers.
- (7) Electroplating, W. Blum.
- (8) Gas chemistry, E. R. Weaver.

The Optics Division, C. A. Skinner, chief. Sugar chemistry and the chemistry of photography.

The Electrical Division, E. C. Crittenden, chief. Electrochemistry and the chemistry of underground corrosion.

The Division of Organic and Fibrous Materials, W. E. Emley, chief. Rubber, textiles, paper, leather and farm wastes.

The Division of Clay and Silicate Products,[1] P. H. Bates, chief. Ceramic chemistry.

The Metallurgy Division, H. S. Rawdon, chief. The chemistry of metals and alloys.

The Heat and Power Division, H. C. Dickinson, chief. Thermodynamics and petroleum chemistry.[1]

The Chemistry Division was organized as a separate division in 1903 under the direction of Dr. W. A. Noyes as chief chemist. Under Dr. Noyes' direction, a number of noteworthy investigations in the field of atomic weights of the elements were completed and published. Dr. Noyes resigned in 1907 to become head of the Chemical Department at the University of Illinois and was succeeded by Dr. W. F. Hillebrand. Dr. Hillebrand's administration was characterized by an intensive program of research in the improvement of methods of quantitative analysis, the results of which are to-day represented by numerous contributions to the literature, by a scholarly treatise on "Quantitative Analysis" under the joint authorship of Hillebrand and Lundell, by a highly trained personnel, and by the establishment of the Bureau's set of standard samples for analysis and testing. These certified samples now number 100 and have a world-wide distribution. (See Fig. 1). The Chemistry Division is organized in sections, as shown above.

The chemical work of the Bureau is of two types: (1) routine analysis and testing, and (2) research.

The analysis and testing work is confined almost entirely to materials purchased by various branches of the government and is for the purpose of ascertaining whether manufacturers' products meet the government specifications. The testing work of the Chemistry Division is under the immediate supervision of P. H. Walker, assistant chief of the division, and its volume is so great that it occupies the full time of the larger part of the personnel. During

[1] The chemical work of this division will be discussed in a later paper of this series.

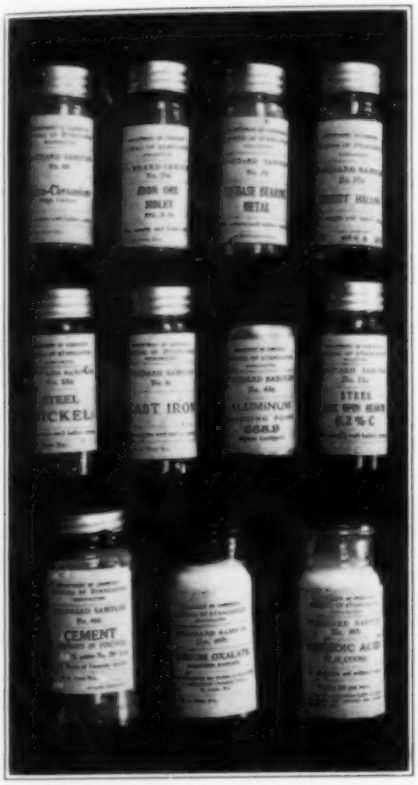


FIG. 1. PACKAGES OF STANDARD SAMPLES

CERTIFIED AS TO EXACT CHEMICAL COMPOSITION OR AS TO ONE OR MORE PHYSICAL PROPERTIES. 100 DIFFERENT SAMPLES ARE AVAILABLE FOR DISTRIBUTION. THE COMPLETE LIST, WITH PRICES, CAN BE OBTAINED BY APPLICATION TO THE BUREAU.

the fiscal year 1931–32, 16,059 different samples of material or products were tested.

Research work is carried on in each of the sections of the Bureau referred to above and covers a great variety of topics, only a few of which can be mentioned.

With the cooperation of the American Petroleum Institute the Chemistry Division has been working during the last five years on the problem of the constitution of petroleum, in particular the problem of separating it into its constituent hydrocarbons and identifying these hydrocarbons. To date thirty-two different hydrocarbons have been isolated, chiefly by purely physical methods, comprising distillation (See Fig. 2), crystallization and extraction. The results of this work have been published in twenty-five papers.

Other current research work in phys-

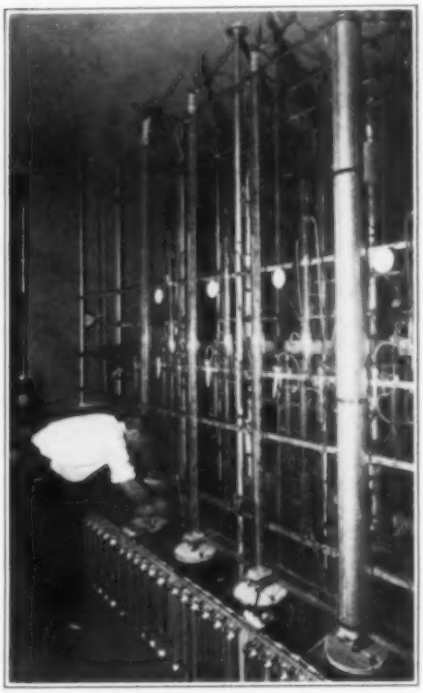


FIG. 2. SCENE IN THE DISTILLATION LABORATORY

SHOWING A BANK OF STILLS WITH TALL FRACTIONATION COLUMNS. THE COLUMN HEIGHTS VARY FROM TWO FEET TO THIRTY-FIVE FEET AND INCLUDE THE BUBBLE-CAP AND PACKED COLUMN TYPES. ALL STILLS ARE OF GLASS WITHOUT JOINTS AND ARE PROVIDED WITH MEANS FOR CONTROLLING THE TEMPERATURE, THE PRESSURE, THE REFLUX RATIO AND THE NATURE OF THE ATMOSPHERE WITHIN THE STILL. THE DISTILLATE PASSES CONTINUOUSLY THROUGH A SMALL COTTRELL BOILER WHICH SHOWS THE TRUE BOILING POINT OF EACH FRACTION COLLECTED.

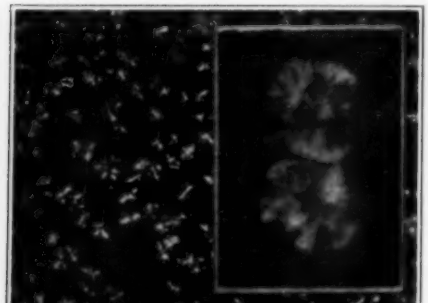


FIG. 3. CRYSTALS OF RUBBER

PHOTOGRAPHED BETWEEN CROSSED NICOLS, MAGNIFICATION 200× (AND 500×), TEMPERATURE −60° F. THESE CRYSTALS MELT AT 50° F. THEY ARE OBTAINED BY COOLING A DILUTE ETHEREAL SOLUTION OF PURIFIED RUBBER.

ical chemistry includes the accurate determination of the heats of chemical reactions, phase equilibrium data at high temperatures, and the preparation and properties of the isotopes of hydrogen and oxygen.

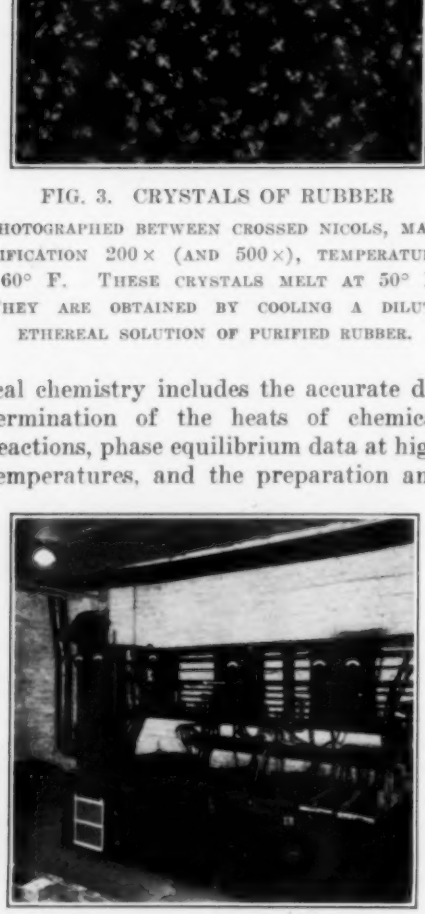


FIG. 4. THE ELECTROPLATING LABORATORY

SHOWING THE GENERATOR, THE ELECTROPLATING BATHS AND EQUIPMENT FOR CARRYING OFF FUMES.

In organic chemistry the problem of the chemical nature of rubber is being systematically attacked and for the first time it has been found possible to crystallize the rubber hydrocarbon (see Fig. 3) and thus probably to separate it into chemical individuals whose properties and composition can be determined.

In general analytical chemistry, the research work is devoted to the development and improvement of analytical methods to meet the new situations which constantly arise through the appearance of new alloys and other products and the increased demands for more accurate chemical control of industrial processes. New types of standard samples must also be created from time to time to meet the changing needs of industry.

In electrochemistry the emphasis is largely upon the scientific and technical problems encountered in the electroplating of the various metals. In particular a series of noteworthy contributions has been made to the problems connected with chromium plating (see Fig. 4) and to the development of new uses for this extremely hard and permanent protective coating.

The section on the chemistry of the platinum metals is gradually bringing to completion a systematic scheme for the quantitative analysis of mixtures containing any or all of these six metals and has recently published a new determination of the atomic weight of osmium (see Fig. 5).

The gas chemistry section devotes a large part of its efforts to the development of the principles of design and testing of gas burners for domestic and industrial appliances to the end that these burners shall function efficiently under various conditions of service and without danger of producing the deadly

carbon monoxide gas (see Fig. 6). In this work the section is also closely associated with the public utility commissions of the states in the development of service standards.

In addition to its own research work, the Chemistry Division assists in the work of many of the other divisions of the Bureau through the analysis of materials and by the preparation of pure substances.

The Polarimetry Section of the Optics Division conducts work incidental to assisting the Treasury Department in the maintenance and operation of its customs laboratories. The bulk of this work is in connection with the testing of raw sugars and molasses for purposes of appraisal under the provisions of the Tariff Act. The bureau also acts as referee in disputes between buyers and sellers of molasses and other sugar products.

The Bureau's work on the preparation of exceedingly pure sucrose brought to light the existence of an error in the scale of the saccharimeter, the correction of which has led to an increase of over $200,000 annually in the amount of import duty collected upon the raw sugar entering the country.

In addition to the analytical work referred to above, the Polarimetry Section has contributed much to the world's knowledge of the chemistry of the sugars and related compounds. Its work has a two-fold purpose, first, to find more efficient ways of preparing and handling these carbohydrates, and second, to learn their chemical and physical properties as well as to obtain an insight into their molecular structures. That such studies may result in applications of extreme importance in our every-day economic life is evidenced by the extraordinarily rapid development of the corn sugar (dextrose) industry immediately after this Bureau demonstrated that dextrose, through proper handling, could readily be obtained on a commercial scale in a crystalline state in a general way analogous to that of ordinary cane sugar.

For many years the Bureau has found much of interest in the study of levulose, the sweetest of all the sugars, the most important one occurring in honey, and which constitutes 50 per cent. of the inversion products of our ordinary cane or beet sugar. In addition to being perhaps the most wholesome of all the sugars and possibly even considerably more assimilable by diabetics than ordinary sugar, it may be produced from a crop which is easily grown in almost all sections of this country, namely, the Jerusalem artichoke. For a long time a knowledge of the peculiarities of this

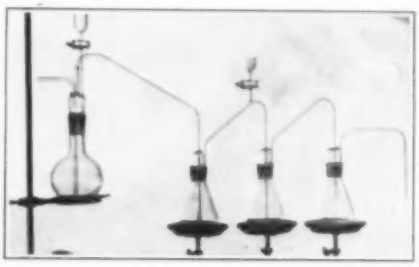


FIG. 5. APPARATUS USED IN THE DETERMINATION OF OSMIUM

THE OSMIUM SOLUTION ACIDIFIED WITH NITRIC ACID IS HEATED IN THE FLASK ON THE LEFT. THE VOLATILE OsO_4 IS DRIVEN OUT AND ABSORBED IN HCl SATURATED WITH SO_2 IN THE THREE ABSORPTION FLASKS, WHERE IT IS OBTAINED AS THE COMPOUND H_2OsCl_6.

sugar was limited by the difficulty of preparing crystalline derivatives which could be purified and studied. Gradually, however, many types of derivatives have been prepared and studied. One of the most important, at least from the standpoint of the preparation of the sugar, is a compound formed between levulose and lime which, being almost insoluble, serves to separate the levulose from the impurities which accompany it

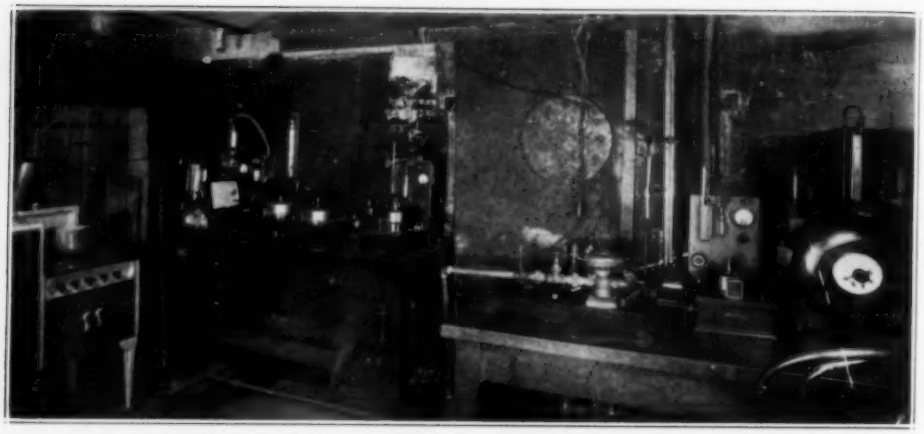


FIG. 6. ALTITUDE CHAMBER

WITH EQUIPMENT FOR TESTING THE BEHAVIOR OF GAS APPLIANCES UNDER CONDITIONS WHICH PREVAIL IN MOUNTAINOUS REGIONS.

in the plant juices and which retard its crystallization. A method of preparation based upon this derivative, and taking into account the chemical and physico-chemical properties of the levulose as previously determined, has been perfected on a semi-commercial scale, using apparatus capable of handling approximately one half ton of sugar per day (see Fig. 7).

Particular attention has been directed to the preparation of the aldonic acids. These substances are the simplest oxidation products of certain sugars, such as dextrose, xylose and lactose. One possible practical application of these substances is in the removal of boiler scale. A method of preparing these sugar acids at a reasonable cost has been developed and a Public Service Patent taken out to prevent it from being monopolized by private interests.

A large number of scientific papers dealing with the Bureau's discoveries in the realm of the rare sugars have been published in recent years.

The work of the Photographic Emulsion Laboratory, also in the Optics Division, may be described as the application of physical chemistry to problems of photographic sensitivity. Experimental emulsions are prepared under chemical control, the use of the silver electrode for this purpose having been developed in this laboratory. Special attention has been given to color sensitization.

The chemical work of the Division of Organic and Fibrous Materials has been directed chiefly towards the application of science to industry. Occasionally, however, it has been necessary to make excursions into the realms of pure science in order to obtain needed facts, as, for example, the molecular structure of collagen and the electrophoretic behavior of silk and wool.

Organic chemistry does not have a system of quantitative analysis which is generally applicable. Each problem is considered separately, and the methods adopted are subjected to continuous study and revision. The Bureau's method of analysis of wool-cotton mixtures has been given official standing by the Federal Trade Commission, and its method for estimating the amount of tin in weighted silk has been generally accepted by the industry. Extra refinements are sometimes called for, as in the case of cloth for rubberizing, which must

contain less than 0.001 per cent. of copper or 0.0005 of manganese.

The natural deterioration of organic materials is accompanied by chemical changes. Quantitative estimation of the end products affords a means of following the progress of the reactions, and of determining the values of accelerated aging tests. Thus the alpha cellulose content and copper number of paper, before and after accelerated aging, give information of value in predicting the probable life of the paper. The quantity of water-soluble nitrogen compounds which have been produced by hydrolysis of hide substance is dependent upon the past history of a piece of leather.

Acidity is an important cause of natural deterioration. It may occur as a result of the manufacturing process, or as sulphur compounds absorbed from the air. Its deleterious effect on cotton, paper and leather has been studied. For this purpose it has been necessary to develop methods for measuring minute quantities of sulphur dioxide and trioxide in these materials, and to investigate the effects of ferric iron and of sunlight in analyzing the oxidation of the dioxide to the trioxide. In the study of such wastes as cornstalks and

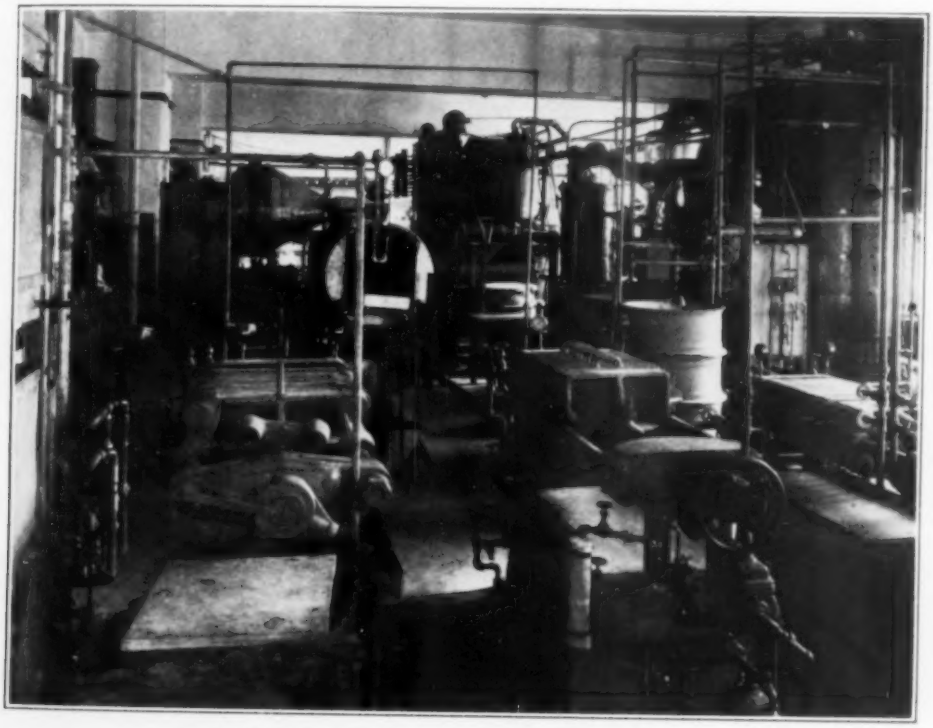


FIG. 7. LEVULOSE EXPERIMENTAL FACTORY

SHOWING FILTER PRESSES, GRANULATOR, EVAPORATORS AND CRYSTALLIZERS. JERUSALEM ARTICHOKE TUBERS ARE SLICED, EXTRACTED IN A DIFFUSION BATTERY, THE JUICE HYDROLYZED WITH ACID, NEUTRALIZED, CALCIUM LEVULATE PRECIPITATED, FILTERED OFF, TREATED WITH CO_2 GAS, AND THE PURE LEVULOSE LIQUOR CLARIFIED BY FILTRATION AND EVAPORATED TO CRYSTALLIZE THE LEVULOSE WHICH IS OBTAINED AS A BEAUTIFUL WHITE PRODUCT WITH A DELICIOUS TASTE—THE SWEETEST OF ALL THE SUGARS.

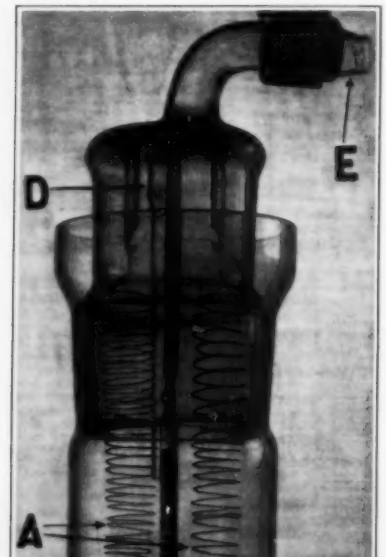


FIG. 8. SPRING BALANCE

WITH SPRING OF SILICA-GLASS FIBER, FOR DETERMINING ADSORPTION AND DESORPTION BEHAVIOR OF FIBROUS MATERIALS. THE MATERIAL TO BE STUDIED IS SUSPENDED FROM THE HOOK AND THE PRESSURE OF THE WATER VAPOR IS CONTROLLED THROUGH THE OPENING, E, WITH THE AID OF A VACUUM PUMP.

straw, complete electrometric titration curves are necessary to identify the various organic acids which may be present.

The water content of an organic material varies with the atmospheric humidity, and there is a corresponding important variation in the physical properties of the material. Practically, water is estimated by drying under certain empirical conditions. But one can never be sure under the given conditions, either that all of the water is removed, or that some of the loss does not consist of volatile material other than water. This question is therefore being studied by means of complete absorption-desorption curves (see Fig. 8).

Cotton seed linters, peanut shells, corncobs and similar wastes contain upwards of 25 per cent. of xylose. A semi-commercial plant has been built to extract this xylose in pure crystalline form, and several tons have been made. It is believed that the information obtained in this work will ultimately become the foundation of a new chemical industry.

Metallurgy

A Division of Metallurgy was established at the Bureau of Standards in 1913 under the direction of the late Dr. George K. Burgess. Under his able leadership the division grew into substantially its present form. It is housed in a building constructed to meet its special needs and at present has a staff of 44 employees. When Dr. Burgess was appointed director of the Bureau in 1923, he was succeeded by H. W. Gillett as chief of the division. Dr. Gillett resigned in 1929 to become director of the Battelle Memorial Institute and was succeeded by H. S. Rawdon, the present chief of the division. The present organization of the division comprises the following sections:

(1) Optical metallurgy. D. J. McAdam, Jr.

(2) Thermal metallurgy. L. Jordan.

(3) Mechanical metallurgy. W. H. Swanger.

(4) Chemical metallurgy. J. G. Thompson.

(5) Experimental foundry. C. M. Saeger.

Metallurgy is most properly defined as "the art of extracting metals from their ores and of fitting them for practical use." The second part of the definition is just as important as the first and, in fact, most of the striking advances that serve to characterize "modern metallurgy," as distinguished from metallurgy of former days, have been made along this line.

Metallography, the study of the structure of metals, macroscopic, microscopic, and atomic, and its correlation with the observed physical properties, plays an exceedingly important part in modern metallurgical study. Likewise does the physical chemistry of mixed metals, whereby the rationale of alloy-formation has been put on a sound basis. The changes in the structure and properties of metals with temperature and the control of these changes form the basis of modern heat treatment. The plastic flow of metals under stress underlies the mechanical working of metals by rolling, forging, drawing, swaging, extrusion and the like. (See Figs. 9 and 10). It is with this general aspect of the subject of metallurgy which has been aptly called "physical metallurgy," to distinguish it from "chemical or process metallurgy," which relates to the recovery of metals from their ores, that the metallurgical work of the Bureau of Standards is almost entirely concerned.

An outstanding example of the successful application of the metallographic method in an industrial way came as a result of the pioneer work of the Bureau on duralumin a number of years ago. The explanation advanced for the "spontaneous" changes in hardness and strength which characterize this light aluminum alloy has formed the basis of numerous subsequent developments of alloys which respond to "precipitation hardening." In particular, many nonferrous alloys can be hardened by heat treatment—a development entirely unsuspected on the basis of the older conventional ideas of metallurgy and attributable to the Bureau's metallographic study of the duralumin problem.

Duralumin has not always given satisfaction in service, however, as a structural material. Instances have been noted in which it has become weak and very brittle in use. Extensive laboratory study at the Bureau of Standards, supplemented by exposure tests to the weather extending over a period of five years, have served to show definitely, however, the conditions responsible for the undesirable and erratic loss of strength and also how this change can be prevented. Duralumin can now confidently be regarded as a reliable material for engineering structural purposes for most conditions.

As part of this work many proposed means for protecting duralumin structures were studied. The results have demonstrated conclusively the usefulness

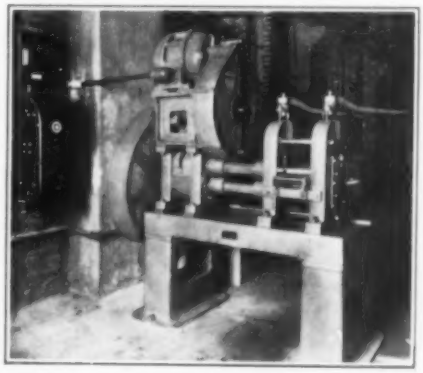


FIG 9. ONE OF THE ROLLING MILLS AVAILABLE FOR STUDYING THE MECHANICAL WORKING OF METALS. A BENCH FOR WIRE-DRAWING IS PARTIALLY SHOWN IN THE BACKGROUND.

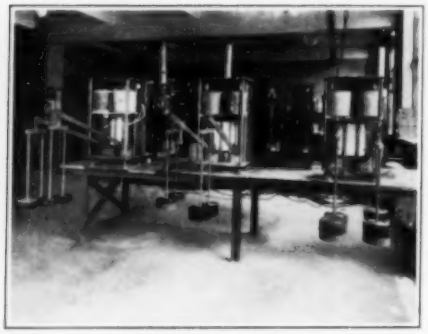


FIG. 10. HIGH TEMPERATURE TESTING EQUIPMENT

BY MEANS OF EQUIPMENT OF THIS KIND, THE TENSILE PROPERTIES OF METALS AT HIGH TEMPERATURES ARE STUDIED, ESPECIALLY THEIR TENDENCY TO "CREEP" UNDER LOAD. THE TEST OF A MATERIAL MAY BE OF SEVERAL MONTHS' DURATION.

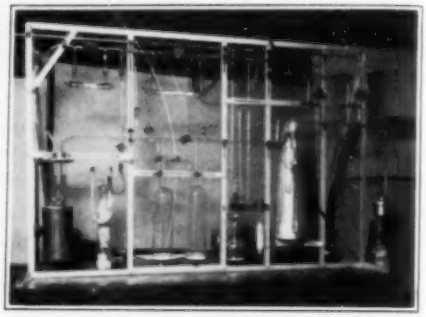


FIG. 11. ANALYTICAL TRAIN

USED IN THE DETERMINATION OF "GASES" IN METALS. OXYGEN, HYDROGEN AND NITROGEN ARE DETERMINED IN THE SAMPLE WHICH IS MELTED IN THE HIGH-FREQUENCY INDUCTION FURNACE AT THE EXTREME RIGHT. THE EVACUATION OF THE TRAIN IS ACCOMPLISHED BY MEANS OF THE MERCURY DIFFUSION PUMP SHOWN.

of the anodic-oxidation treatment and a new method for carrying out this treatment has been recently developed for the Navy Department's use. Results obtained with duralumin coated with pure aluminum were so encouraging that the commercial development of "Al-clad" duralumin—the most dependable of all of the high-strength light alloys for structural purposes—followed, and ranks as one of the high spots in development of the aluminum-alloy industry.

"Gases in metals" has been made the scapegoat by many metallurgists for any and every unsatisfactory characteristic of metals not readily explainable otherwise. Without question many obscure characteristics of metals, such as the "body" or quality of tool steels, the abnormal behavior of certain steels when carburized, the changes in the properties of low-carbon steels on aging, etc., are intimately related to oxides and perhaps to other "gases" within the metal.

In view of the industrial importance of the problem, considerable time has been spent at the Bureau of Standards in the development of analytical methods for "gases" in steel. (See Fig. 11). The method depending upon the recovery of the gases evolved upon fusion of the metal *in vacuo*, which was perfected, is now quite generally used by all workers in this field. The study of the so-called "abnormality" of steels showed that the deoxidation treatment was largely responsible for the conditions, as it was also for the inferior properties of many steel castings.

An allied study is the attempt now in progress to prepare iron of very high purity. The properties of *pure* iron, the basis of all steels, are almost unknown, since various indeterminate amounts of "gases" are present in all "pure" irons previously prepared. The present method, depending upon large-scale chemical operations of precipitation, reduction, etc., rather than upon electrodeposition, or deoxidation in the molten stage, promises to give material exceeding in purity any previously described "pure iron." Similar work on pure nickel has already been done and published.

Of all metallurgical shop operations, that of casting, which has been practised from time immemorial by rule-of-thumb methods, is perhaps the most fertile field for technical study and improvement. (See Fig. 12). The Bureau's studies of foundry sands have aided very materially along this line. Marked advances are being made in this subject whereby the purchase, use and "control" of foundry sands are being put upon a sound technical basis. A good beginning has been made in the study of the factors upon which successful casting operations depend, such as the determination of the "running" properties of a metal cast in a foundry mold, and the distribution of the shrinkage of a metal during casting as related to the liquid phase, the period of solidification and the solid phase.

An outstanding foundry accomplishment is the development of a rubber binder for sand cores. Cores can be made by this means which require no preliminary baking and which disintegrate after they have served their purpose, thus facilitating their removal from the casting.

The deterioration of metal parts in service can usually be traced to one or more of the following factors: wear, corrosion and fatigue. These three form the subject of a number of the metallurgical researches now in progress. One of the outstanding projects under way is the study of steel bridge-cable wire. Wire, especially in the form of cables, is an important structural material for bridge and other construction. The attempt a few years ago to utilize modern methods of heat treatment of the time-honored

FIG. 12. ELECTRIC FURNACES IN THE EXPERIMENTAL FOUNDRY

FOR THE MELTING OF METALS. THE ONE IN USE IS A TILTING HIGH-FREQUENCY INDUCTION FURNACE.

cold drawing process in the preparation of such wire for suspension bridge construction ended in disastrous failure and the dismantling of two bridges. Several very important facts bearing on the subject have already been disclosed. A somewhat analogous problem is that of rail steel, the propensity of which to failure in service by the development of internal fissures constitutes a serious liability in the maintenance of the railroad tracks. The Bureau's work has shown that the steel possesses low ductility at elevated temperature over a considerable range of temperature. Internal-shrinkage cracks form on cooling. Several processes, based upon this work for controlling and remedying the situation, are now coming into practical use in the steel mill.

The problem of deterioration by wear is extremely important in the industrial use of metals. The fundamental factors involved in wear-resistance are receiving much study. Oxidation or corrosion during wear is an important factor. In the field of bearing metals much has been accomplished in determining the characteristic properties of bearing alloys at service temperatures and the development of alloys which will serve to conserve tin—a strategic material—if the necessity should arise. This is distinctly a governmental research.

Until relatively recently, the heat treatment of steel has been strictly a rule-of-thumb procedure. The Bureau's work on the quenching of metals, the importance of which was recognized by the American Society for Steel Treating in the medal bestowed upon the investigator in charge, has aided in no small degree in raising the status of this subject.

In addition to investigative work, the Bureau is called upon by other departments for metallurgical testing work. Very little of this can be classed as routine, however; nearly every one is a minor research such as the investigation of failure of metals in service.

The results of the Bureau's researches in metallurgy have been published in some 460 different papers.

CANYONS BENEATH THE SEAS

By Dr. FRANCIS P. SHEPARD
UNIVERSITY OF ILLINOIS

HALF a century has elapsed since Captain Lindenkohl discovered that the soundings of the ocean bottom off New York harbor indicated a submarine continuation of the Hudson River valley. Examination of the charts from other parts of the world showed similar features, and as charting became more complete it was found that deep submarine canyons were incised into the ocean floor in numerous places off all the continents. Many of these submarine depressions were found to extend to depths of over a mile and to have steep walls thousands of feet high.

About thirty years ago the subject of submarine canyons was discussed in many scientific articles. The American geologist A. C. Spencer and the British geologist Edward Hull drew elaborate maps showing continuations of the great river valleys of Europe and America out into the depths of the Atlantic.[1] They concluded that the valleys were cut by rivers at a time when the continents were elevated thousands of feet above their present levels. They considered that this uplift produced a change in temperature sufficient to bring on the great ice sheets of the glacial period. One fatal weakness to the last assumption developed when the evidence became more and more convincing that the glacial period included at least four and perhaps five epochs of glaciation separated by times of mild climate. To have maintained the idea of elevation as a cause of climatic changes it would have been necessary to assume a series of uplifts and sinkings of great magnitude within what is considered by geologists to be a very short period. The weight of evidence suggesting that large changes of the land surfaces have been very slow and that the continents have been relatively stable in relation to the ocean basins has caused most geologists to disregard this evidence of elevation, and for some time the submarine valleys have been relegated to the oblivion which often absorbs the phenomena which do not appear to fit into current hypotheses.

In the old surveys the soundings in submarine valleys were generally so diffuse and so inaccurately coordinated that an investigator had little means of determining the form of the features.[2] Recently the United States Coast Survey vessels have been equipped with devices which readily obtain closely spaced soundings, even in deep water, locating these soundings with great accuracy, even well beyond sight of land. The soundings are taken by the accurate measurement of the time between the sending of a sound impulse from the hull of the ship and the receiving of an echo of this sound, an interval which is proportionate to the distance from the ship to the bottom. The locations are determined by a similar method in which sound is developed by bombs, and the distance between the survey ship

[1] A. C. Spencer, "Submarine Valleys off the American Coast," *Bull. Geol. Soc. Am.*, 14: 208, 1903; Ed. Hull, "Sub-Oceanic Physiography of North Atlantic," London, E. Stanford.

[2] Descriptions of the canyons by Spencer and others were far more detailed than the data warranted. The mention of a waterfall in the course of the submarine valley of the Hudson, for example, was due to a lack of understanding of the limitations of surveying out of sight of land.

and two vessels anchored in established positions is found by means of a chronograph and wireless relays. Many of the submarine valleys off the west coast of the United States have been surveyed, using these new methods and in the summer of 1932 a series of tremendous canyons was discovered and surveyed off the coast of New England. This recent information, taken in conjunction with the earlier work, makes it possible to pursue a more promising investigation into the mysteries of the sea floor canyons.

Comparison with Land Canyons

The valleys of the ocean bottom have proven to be of a size and depth quite comparable with our Western canyons and may even match in vastness the Grand Canyon of the Colorado. A section made from wire soundings across the deepest submarine canyon so far discovered and a section across the Grand Canyon, using the same number of observations and the same spacing, will illustrate this comparison (Fig. 1, c and d). The insignificance of the Yellowstone Canyon compared to one of the canyons off the New England coast is also striking (Fig. 1, a and b). Whether the submarine canyons contain anything comparable to the remarkable terraces and buttes of the Grand Canyon can not be told as yet, since even the echo-sounding profiles give only a generalized section because echoes come from the nearest good reflecting surfaces rather than from points directly beneath the vessel. However, there are some indications of highly irregular sections across certain of the canyons off the west coast.

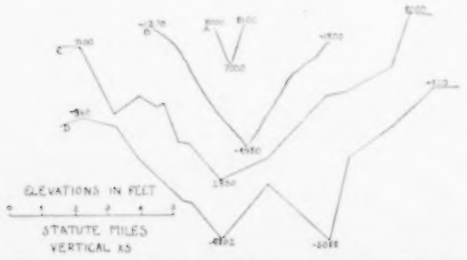


FIG. 1. A COMPARISON OF THE CROSS SECTIONAL VIEWS OF LAND AND SUBMARINE CANYONS.

A REPRESENTS THE YELLOWSTONE CANYON. B IS FROM A RECENTLY DISCOVERED CANYON OFF THE NEW ENGLAND COAST. C AND D REPRESENT THE GRAND CANYON AND A CANYON OFF THE COAST OF NORTHERN CALIFORNIA. THE SCALE IS THE SAME FOR EACH. THE NUMBER OF OBSERVATIONS ON WHICH C IS BASED WAS MADE TO CORRESPOND TO THE NUMBER AVAILABLE FOR D.

Origin of the Submarine Canyons

Despite the absence of minute details in the present surveys of submarine canyons, there appears to be enough general information to allow some tentative conclusions to be drawn concerning their origin. In the past several theories have been presented to account for them. Besides the idea that they were the result of river cutting in a temporarily emergent sea bottom, they have been attributed to faulting or rifting of the earth's crust, to powerful submarine currents, and to the collapse of subocean caves.[3] However, the character of the canyons is difficult to explain in any of these ways.

Faulting and Rifting: Deep valleys on land have been formed by the slow down-sinking of blocks of the earth's crust, as in the case of the Jordan-Dead Sea Valley in Palestine and Death Valley in California. Other valleys have been attributed by some geologists to the pulling apart of the earth's crust, as, for example, the Rift Valleys of East Africa.[4] Valleys produced by

[3] For a more complete discussion of these ideas than will be presented here the reader may consult an article by the writer entitled "Submarine Valleys" (*Geographic Review*, January, 1933).

[4] These valleys may be due to simple down-faulting, an opinion held by other geologists.

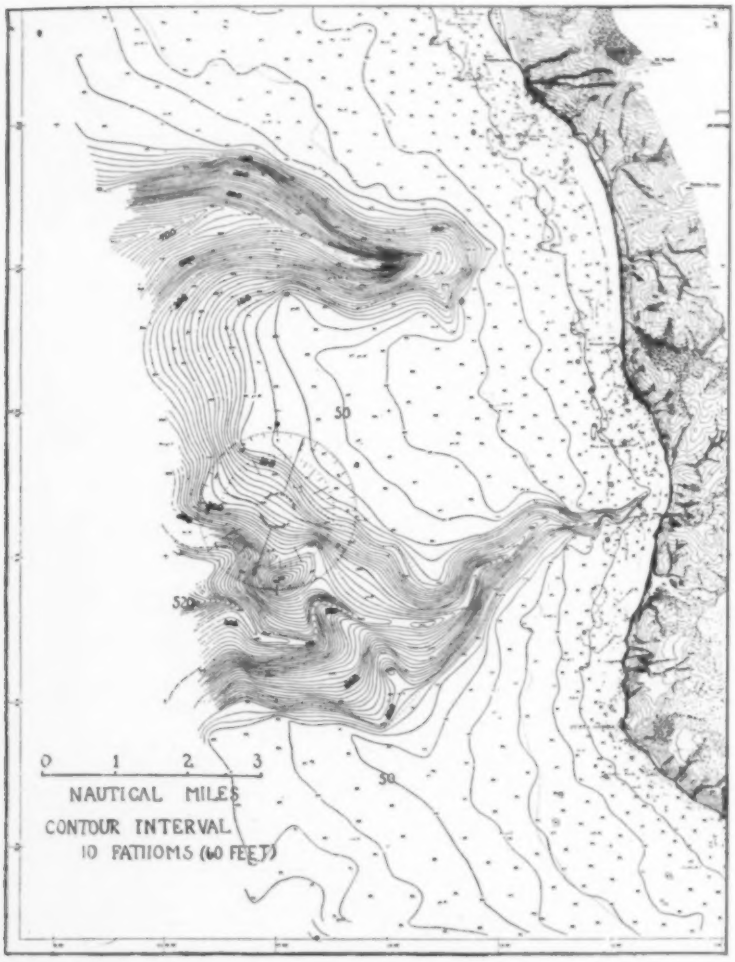


FIG. 2. TWO CANYONS OFF THE COAST OF CALIFORNIA NEAR CAPE MENDOCINO.

THE SHAPE OF THE CANYONS IS EXPRESSED IN CONTOURS BELOW SEA-LEVEL. THESE CONTOURS CONNECT POINTS OF EQUAL DEPTH, JUST AS LAND CONTOURS CONNECT POINTS OF EQUAL ELEVATION. ACCORDINGLY, VALLEYS ARE SHOWN BY THE BENDING OF THE CONTOURS TOWARDS THE COAST AND THE STEEPNESS OF VALLEY SLOPE IS SHOWN BY THE SPACING OF THE CONTOURS, A STEEP SLOPE HAVING CLOSE SPACING. THE FIGURES REPRESENT FATHOMS. CONTOURING BY THE LATE PROFESSOR H. H. ROBINSON FROM SOME CHARTS KINDLY FURNISHED TO THE WRITER BY MRS. MABEL ROBINSON.

either of these processes have some characteristic features of topography, such as straight sides, steep walls, broad relatively flat bases, and in most cases uplifted irregular blocks adjacent to them. The typical submarine valleys, on the other hand, have curved patterns, V-shaped bases, and in their inner por-

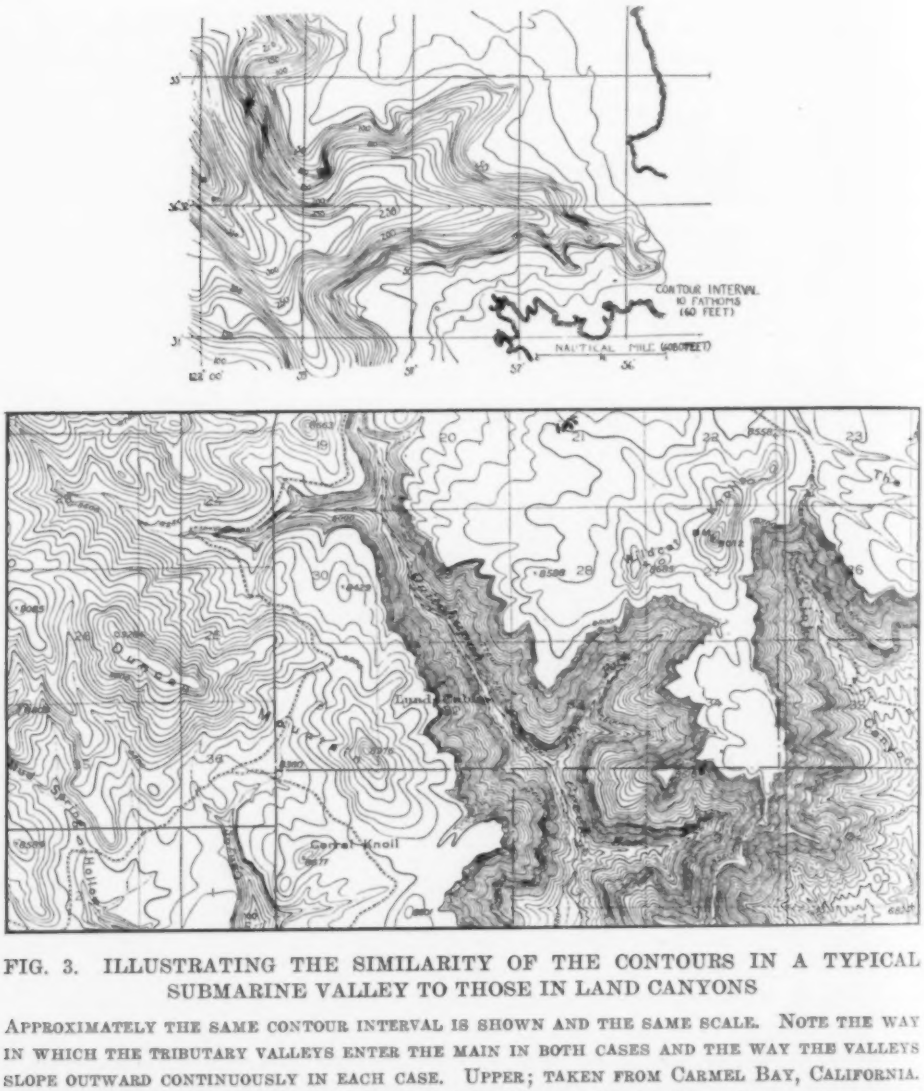


FIG. 3. ILLUSTRATING THE SIMILARITY OF THE CONTOURS IN A TYPICAL SUBMARINE VALLEY TO THOSE IN LAND CANYONS

APPROXIMATELY THE SAME CONTOUR INTERVAL IS SHOWN AND THE SAME SCALE. NOTE THE WAY IN WHICH THE TRIBUTARY VALLEYS ENTER THE MAIN IN BOTH CASES AND THE WAY THE VALLEYS SLOPE OUTWARD CONTINUOUSLY IN EACH CASE. UPPER; TAKEN FROM CARMEL BAY, CALIFORNIA. LOWER; FROM THE U. S. TOPOGRAPHIC SHEET, ACORD LAKES, UTAH. THE HEAVY CONTOURS ARE AT INTERVALS OF 250 FEET.

tions are flanked by the relatively even-floored continental shelves[5] (Figs. 2–4).

Ocean Currents: In some places the currents produced by the tides are sufficiently powerful to erode even rock bottom so that it is conceivable that they might produce submarine canyons. However, the strong tidal currents are confined, so far as we know, to narrow inlets along the coasts and are probably quite powerless out on the open continental shelves where the deep canyons have been discovered. The finding of

[5] Continental shelves are the shallow platforms which extend seaward with gentle slopes off most of the coasts of the world.

muddy bottom in many of the canyons and sandy bottom along the adjacent continental shelves suggests that the conditions in these canyons are quieter than on the shelves or the fine sediment could not come to rest. Some observations by fishermen appear to check this suggestion of quiet conditions in the valley bottoms. Probably currents have little to do with valley formation, but this view should not be considered as final until more observations have been made.

Collapse of Sub-oceanic Caves: Underground water certainly does circulate to some extent beneath the margins of the ocean. This has been proven by the springs and wells of outlying islands and by the gushing out of fresh water into the ocean in shallow water near shore. In order to produce a submarine canyon by circulation of this water several conditions would be essential. A layer of soluble material would have to underlie insoluble, relatively impervious material and this layer would have to extend out almost at right angles to the coast. Water circulating in the soluble layer could emerge only at great depths in the continental slopes[6] during the formation of the cave. The cave roof would have to collapse along practically its entire length in order to produce a valley-like depression. Even under these ideal and almost impossible conditions only a relatively shallow valley could be formed, since caves never acquire great vertical dimensions, except around sink-holes. Furthermore, the soluble rocks favorable to the formation of caves do not exist on shore opposite most of the submarine valleys.

River-cut Valleys: There are a number of reasons for believing that the submarine valleys were cut by rivers. They are found directly off the mouths of many large rivers, such as the Indus, the Ganges, the Congo, the Niger, the Hudson, the Mississippi and the Columbia. In their inner portions they have the V-shaped transverse profiles which characterize the early stage of valley cutting by rivers in regions of high relief. They have the sinuous courses typical of river valleys and in some cases the dendritic (tree-like) pattern of a river valley system (Fig. 3). Also most of the valleys extend across the continental shelves and down the continental slopes in the direction which one would expect a river to take if the shelf and slopes were laid bare.

On the other hand, there appear to be objections to the idea of a fluvial origin for the valleys. The enormity of the uplift and sinking necessary, as stated above, is somewhat staggering to the imagination, especially since almost all the coasts of the world are involved. Many of the submarine canyons head near coasts which have no near-by land valleys. Also the drowning of a river valley system should produce large estuaries, like Chesapeake Bay, for example, but the submarine canyons are found off relatively straight stretches of coast. The nature of the continental shelves is especially hard to reconcile with the idea of major earth movements. These shelves have a remarkable tendency to terminate at depths varying from 300 to 500 feet, and the shelves adjacent to the submarine canyons do not form exceptions to this rule. Huge movements of the continental shelves in recent times should have destroyed this uniformity.

A lowering of the sea-level could have allowed the cutting of the valleys into the shelves and slopes beyond. This explanation removes some of the difficulty regarding the uniformity of shelf edge, but is open to equally serious objections. Since the valleys extend to depths of one or more miles, this hy-

[6] Continental slopes are the steep inclines which connect the gently sloping continental shelves with the deep ocean floors.

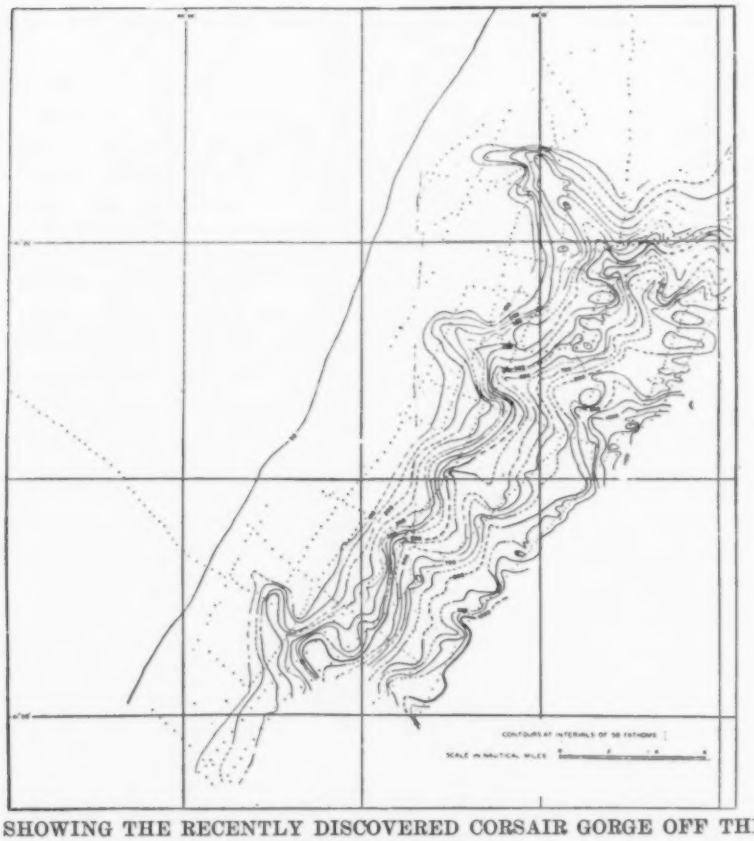


FIG. 4. SHOWING THE RECENTLY DISCOVERED CORSAIR GORGE OFF THE NEW ENGLAND COAST.

THERE IS REASON TO BELIEVE THAT THIS GORGE WAS REOPENED BY A LANDSLIDE AT THE TIME OF THE GRAND BANKS EARTHQUAKE. THE DOTS REPRESENT POSITIONS OF SOUNDINGS. THE SOURCE WAS FROM A 1930 AND 1931 SURVEY BY THE U. S. COAST SURVEY AND ADJUSTMENT OF THE SOUNDING LINES BY THE WRITER.

pothesis would imply the storing of about one half of all the ocean water during the valley-cutting stage. If stored on the lands as glaciers the ice would have had an average thickness of about 15 miles over the entire glaciated territory. This seems both impossible and incompatible with all the evidence. The alternative that the ocean bottom sank and then returned is a possibility, but it implies the sinking of all the ocean floors an average of one or more miles and their return to approximately the former elevation. It is almost inconceivable that the rock under the ocean basins could have been so displaced as to allow such movements, especially over such a short period as would seem to have been involved in the cutting of the steep-sided canyons.

Landslides: Several years of study of the phenomena of submarine canyons brought the writer to the impasse where all the hypotheses which had been suggested previously seemed hopelessly inadequate. Some new process seemed necessary to explain these amazing topographic features. An unusual sequence

of events suggested a clue to the identity of the unknown factor. In the fall of 1929 a world-shaking earthquake disturbed the ocean bottom to the southwest of the Grand Banks of Newfoundland. Submarine cables over a large area were broken in many places and a large tidal wave swept into the coast of Newfoundland and carried away many houses into the sea. A few days later Captain Boule, of the steamship *Transylvania*, reported that the outer continental shelf off the New England coast had been depressed during the earthquake. This report was thought doubtful at the time, but the next summer the United States Coast Survey started to make a new chart of Georges Bank and crossing the locality referred to by Captain Boule they found a new submarine valley called Corsair Gorge (Fig. 4). Evidence from liners employing echo-sounding devices has established the probability that this feature was either formed or enlarged at about the time of the earthquake. If this deep gorge were due to a sudden faulting action, it would have been of a size totally unknown on land and would have shaken the surrounding lands and made a record on the seismographs. Since there are no records of such action, the change must have been slow. On land great avalanches occur without producing seismic waves of important magnitudes and cause changes in the topography which are much more evident than are those accompanying earthquakes. Accordingly, it appeared probable that Corsair Gorge was a product of a large submarine landslide set off by the shaking transmitted from the Grand Banks earthquake. Additional soundings made in the outer portion of the canyon in 1931 revealed hummocky topography characteristic of landslide accumulations.

Here was a new suggestion which at first thought might have been considered as the entire cause of the submarine canyons. In many ways these great valleys are ideally located for such a process to operate. They are associated with the steep continental slopes which would give impetus to sliding. The sediments which have accumulated there are saturated with water, making them subject to slides, particularly in the case of the colloidal clays. Also numerous earthquakes originate along or near the base of the continental slopes and these would provide the motive power to start the sliding process.

A little reasoning, however, will show that landsliding is not an explanation which will account for the shape of the submarine canyons. If we assume that the outer portion of the continental shelf is a great mass of sediment washed out from the land and built out over the ocean floor, this sediment would be unstable and subject to slides, but the scars left by such slides should be lunate or cirque-like, such as those on land. If the shelf is underlain by rather weak rock, slides might occur, carrying masses of the rock down the slopes, but again the scars should be cirque-like. The submarine canyons differ in shape from almost all landslide scars known on the continents.

The situation is improved if we can assume that the valleys were formed long ago and were only reopened by landslides in recent times. If the valleys were cut by rivers many millions of years ago during times of great uplift and then submerged, there would have been time for the cutting of the continental shelves adjacent to the valleys producing the present accordant shelf relations. Also the shore line, greatly indented by the submergence, might have become straightened in the course of time. During these changes sediments would have been deposited in the submerged valleys and if no process had interfered, they would have been en-

tirely filled. However, this sediment fill must have contained much clay and silt, since the bottoms of the valleys were presumably at great depths where quiet conditions exist. Clay and silt, particularly if containing high percentages of colloids, are very subject to sliding. The continuous outward slope and the high gradients of the valley bottoms would also have produced good planes for sliding. It is conceivable that the valleys have been filled or partially filled many times, only to be reopened by landslides.

Some of the other features of the submarine valleys which were troublesome under the older hypotheses become understandable with this new combination hypothesis. Thus the close proximity of the valleys to deltas where sedimentation would eliminate them in short order is not surprising if they have been reopened very recently. In some places the bottoms of the valleys have been found to contain coarse gravel and fragments of rock have been collected from their sides.[7] Since the depths associated with these findings are considerable, only muddy fine-grained sediments or calcareous oozes could be carried there by ordinary processes at present. The coarser material and the rock bottom may have been the result of landslides which carried away the fine material of recent generation and exposed buried surfaces which may have been the product of subaerial conditions in the remote past. Also the hummocks and depressions within portions of the valleys which are revealed by the recent surveys are characteristic of landslide surfaces.

Landsliding may be a very active process on the ocean floor at the present time. Means of comparing old and new depths are not available except in a very few places,[8] but there are at least three cases where changes in the bottom of large magnitude seem highly probable. Besides Corsair Gorge, Sagami Bay in Japan and a place along the coast of Peru appear to have been subject to large landslides after earthquakes.[9] Also cable companies have frequently reported the burying of their cables by landslides as well as the severing of cables by the same process.

The Crustal Movements

Since the landslide explanation involves the original cutting of the valleys by rivers, we are still confronted with the problem of the tremendous earth movements necessary to elevate the continental margins and then to depress the truncated land surface beneath the sea. If this had occurred recently there should be abundant evidence along the coasts, but according to the landslide explanation these gigantic movements may have been well back in the geological time scale, so that the traces may have been largely removed. If the uplifts of the various coasts were simultaneous the effect on rainfall in the interior must have been tremendous and the temperature of the elevated tract must have been greatly lowered. However, it is equally likely that the uplifts could have been at widely different times, producing much less world-wide climatic changes.

The character of the deformation

[7] The writer obtained samples of a limestone with quartz pebbles from the sides of a valley off New England in three different places, which makes it probable that these fragments were from a solid rock formation.

[8] In order to make this comparison there must be surveys at two different dates, each of which had an abundance of soundings well located. Slides only occur on or near the steep slopes and these slopes are generally well out from land where locations were very faulty on the old surveys.

[9] For discussion of this evidence see, "Landslide Modifications of Submarine Valleys," *Trans. Am. Geophysical Union* for 1932, pp. 226–230.

which would have produced such changes is difficult to imagine. It might have been in the nature of great upfaulting of blocks along the continental margins or possibly the entire continents were uplifted. According to Joly,[10] radioactivity produces periodic revolutions in the earth's surface causing the continents to rise and fall in relation to the ocean basins. Possibly something of this nature has happened. However, we need to make more of a study of the nature of the valleys before we go more deeply into such speculations.

Suggestions for Future Research

Recently progress in the charting of submarine canyons has been made, but the present information leaves much to be desired. A series of echo soundings across a submarine depression gives only a generalized section. In order to determine whether these canyons have such features as terraces and buttes like the Grand Canyon and whether they show true landslide topography it will be necessary to have a network of soundings made by wire and very closely spaced. Such information is not of sufficient practical importance to warrant coastal surveys undertaking to obtain it. Owners of sizable yachts might find such an investigation an interesting game.

To make such a study buoys should be planted on the continental shelf at the margin of the valleys in order to obtain exact locations. Lines of soundings should then be run back and forth across the valleys, using wire-sounding machines. Plotting these soundings as they were made would show features of unusual interest which might call for more detailed study. Samples obtained from the bottom would greatly add to the value of the undertaking, and determining of the currents in the valley bottom might prove interesting.

[10] John Joly, "Surface History of the Earth," p. 94, 1925.

THE DOMINANCE OF ECONOMICS OVER EUGENICS[1]

By Dr. H. J. MULLER
PROFESSOR OF ZOOLOGY, UNIVERSITY OF TEXAS

IT is now over fifty years since Francis Galton promulgated the doctrine of eugenics. It has become a highly popular subject for parlor talk and best sellers. Yet, aside from some sterilization of imbeciles, we are to-day further than ever from putting eugenic principles into actual operation.

That genetic imbeciles should be sterilized is of course unquestionable, but we should not delude ourselves concerning the importance of the benefits thereof. Following Haldane, we may recall the fact that if (as is commonly claimed but still very doubtful) most imbecility is due to the same recessive gene, then the sterilization of all imbeciles in every generation would not reduce their number to half until about ten generations had elapsed, and subsequent elimination would be even slower. And after all, actual imbecility represents only a very small part of the hereditary weaknesses which a rational genetic therapy would seek to reduce in frequency. Of these various genetic defects, imbecility is by no means the most onerous; firstly, because the imbeciles do not themselves suffer from the consciousness of their defect; secondly, because it is not inhumane to segregate them into institutions, where they constitute much less of an economic and psychological burden on their fellowmen than do many lesser defectives who must remain in the community at large, and thirdly, because, unlike some types who are psychologically abnormal by heredity but who may go about unrecognized as such, they have not the wits to do positive harm on any considerable scale.

The attack on imbecility was to have been only a first step. Yet eugenists (when they have not wandered off into the bogs of caste prejudice) have in the main stuck at that point. The major task of eugenics is not to get rid of this or that specified and highly conspicuous abnormality, such as total hereditary deafness or blindness, existing in relatively rare individuals who might conceivably be subjected, as a class, to outright sterilization. An individual's total genetic fitness (his biologically optimal rate of reproduction) is a complex resultant of manifold variable characteristics, that should be weighted, so far as possible, according to the potential value (+ or −) for society, of the genes by which they are determined. Thus genetic worth is a practically continuous variant, and there is no hard and fast line between the fit and the unfit, nor does relative fitness in the great

[1] This article is based upon an address given before the Third International Congress of Eugenics, in New York City, on August 23, 1932. The author desires to acknowledge that in some of the points herein presented, notably that of the lack of justification for the assumption made by most eugenists, that our present social stratification is positively correlated with genetic worth, he has been influenced by conversations held with Dr. Alexander Weinstein some fifteen years ago (see MS. of the latter, 1918). Some of the other points were expressed by the present author in a MS. of 1909 (address before the Peithologian Society of Columbia University). The attention of readers interested in the present subject may here be called to the symposium on "Heredity and Environment in Man," by Newman, Burks, Weinstein and Hogben, in *The American Naturalist*, May–June, 1933. This symposium was held at the joint meeting of Biological Societies affiliated with the Association for the Advancement of Science, at Atlantic City, December 30, 1932.

majority of individuals depend on one or a few pre-specified genes. It is to be expected, however, that occasional genes of greatly preponderant value will here and there occur, and it is in a general way true that the more advantageous these genes are, and the rarer they are, the greater is their weight, and hence the more important is what happens to them.[2] Now, eugenics requires that conditions be so ordered that the rate of reproduction in the population at large will be positively correlated with the total genetic fitness of the individuals, taken in the sense above stated. When we say that the vital thing, for the population at large, is a relatively low rate of multiplication of those who are, in general, genetically less well equipped, without a decrease in the total size of the population, it is therefore the same as when we say that there must be a relatively high multiplication rate of the better equipped germ plasm. Ideally, the rate should vary directly as total genetic fitness, all along the line, there being, from this point of view, no ultimate distinction between negative and positive eugenics. Since Galton's time, absolutely no headway has been made in realizing this major aim; in fact, it is widely claimed by eugenists themselves that just the opposite process is increasingly operative, despite their own preachments.

What is the reason for this contradiction? We might as well admit that the forces at work here are quite beyond the control of us as eugenists, in the society in which we live. For they are fundamental economic forces. The social direction of human evolution (as Kellicott aptly termed eugenics) can occur only under a socially directed economic system. Galton lived under circumstances and at a time in which we could scarcely expect him to have appreciated the principle, brought out by Marx, that the practises of mankind, in any age, are conditioned by the economic system and material technique existing in that age. He thought that they could be moulded willy-nilly, from without, into conformity with the abstractions of an idealist intellectual. But the organization of society to-day, based on the private ownership of large-scale means of production, is such as to make the primary motive of action, at least among the dominant section, the motive of private profit regardless of others' expense. This motive, operating in connection with our *de facto* socialized physical mechanism of production, works out in devious ways that are antagonistic to the welfare of the race as a whole, despite the fact that some of our modern philosophies, in a defense reaction, try to rationalize the two ends into harmony.

In the first place, it is undeniable that the profit system leaves little place for children. In general, they are not profitable investments: their cost is excessive, the dividends from them are uncertain, they are likely to depreciate in value, are practically non-transferable, and they do not mature soon enough. One child may be necessary for continuance of an estate, but each additional

[2] The potential value, or "weight," of a given gene in a given individual now existing may be regarded as the product, by multiplication, of two different factors. One of these is the amount of advantage (+ or −) to society (including of course the individual himself) which would on the average result from the possession of this gene by an individual. The second factor is the number of descendants who would come to possess derivatives of this very gene, if the latter became optimally multiplied (this is not to be confused with the number that would possess a gene of the very same kind, derived from other individuals now existing). It is necessarily true that the rarer a certain kind of useful gene now is, the greater is the amount of multiplication which any given representative of this kind of gene, now existing, could and (ideally) should undergo, and so the higher will the second factor concerned in the determination of its weight become.

one weakens it. For the great masses, who have no estates, each extra child commonly means more intensified slavery for the parents, and an additional unit of human unhappiness, in itself. And as the status of the middle class sinks, the parents hesitate to rear children with lesser privileges than they.

How much can eugenic considerations weigh in determining the actions of people under these conditions? To what extent will they lead people of greater genetic worth voluntarily to have four, five or even more children (remembering that more than three are usually necessary to a couple, if there is to be any increase at all)? Is it to be wondered at that a census of eugenists themselves has disclosed an appalling failure to reproduce themselves, despite the fact that they are maximally steeped in their own doctrines? Under the conditions that exist to-day, we know very well that it is a rare couple that has four or more children, except as a result of accident, ignorance or superstition, or under atypical conditions that represent disappearing survivals of an older system.

It is true that the universal dissemination of scientific birth control technique would tend to eliminate the production of unwanted children, and to this extent it would bring reproduction under the direction of reason. It is to be welcomed whole-heartedly, as a most important biological invention that increases the potential control of man over natural forces. It will help to fend off a part of the intolerable misery that would otherwise afflict innumerable individual cases, yet we must remember that the economic screws will eventually be forced down again as tightly as they can be anyhow, any relaxation of the pressure from beneath being responded to by a compensatory increase of pressure from above. That is, when the burden of family care diminishes, wages can be decreased still more, so that birth control provides no remedy for the faults of our economic system. Moreover, it must be admitted that birth control, by itself, would certainly not suffice to meet the major needs of eugenics. Not only is it illegitimate to assume that those now unenlightened, whose reproduction would be reduced by the further spread of birth control technique, are genetically inferior, in respect to the traits most valuable for a well-ordered society, but, in technically advanced countries like ours, in which the birth rate as a whole is low, the mere reduction in reproduction rate of any section of the population, uncompensated by an increase elsewhere, would be eugenically inadequate. Even more vital, from a biological standpoint, is an actual increase of those having the more valuable genes, and it is the obtaining of this increase that is prevented by economic pressure, and by social pressure having an economic basis.

In addition to the financial load involved in having children, we must consider the direct burden imposed on the mother. Do male eugenists suffer from the illusion that most intelligent women love to be pregnant and to endure not only the physical disabilities but also the shame and humiliation, and the difficulties of maintaining a job, that pregnancy involves in our society? That they love the frightful ordeal of childbirth, so seldom relieved by competent medical treatment? That they love to spend forty or fifty thousand hours washing diapers, getting up in the night, tending colic, stewing soups and milks, meeting in a city flat their little savages' requirements of safe outdoor activity and companionship, acting as a household drudge, and either abstaining from the life of the outer world entirely or else staggering under the double burden of a very inferior position outside and work in the home as well? It would be physically possible through organized

social services of various types, accompanied by a revolution in our attitude towards women, vastly to ameliorate these afflictions of the female sex, to reduce them, in fact, to the point where the compensations were greater than the disadvantages. But there is no particular profit in bettering the lot of a slave. Meanwhile, intelligent and self-respecting women, and those who value their husband's love, will use what means they may have to restrict the size of their family to a very low level indeed. And in this they will not be wrong. The eugenist, from his glass house, can not criticize them for this.

It is true that subsidies for children have been proposed by some eugenists as a remedy for this situation, but measures that would be really adequate are inconsistent both with the professed principles and with the actuating motives of the private-profit system, with its individualistic ideology. These proposals reveal a total lack of appreciation of the origin and the magnitude of the difficulties above referred to, and of the mechanism of operation and the limitations of our profit system. Within the framework of the latter we can not hope to obtain the wholesale redistribution of goods and services, the complete reorganization of practises and attitudes which alone would suffice to meet the situation confronting us. What is required is no mere individual prizes, doles or other charities, such as might (by a stretch of imagination) be conferred on some favored individuals, but a society consciously organized for the common good so as to assure every one economic plenty, a society meeting fully its obligations both towards the younger generation and towards the older generation who bear and rear the younger. All this presupposes public ownership of the means of production.

A second way in which our economic system acts to foil the true purposes of eugenics is by masking the genetic constitution of individuals and of vast groups through the gross inequalities of material and social environment which it imposes upon them. The investigations of Burks and of the Chicago school on the resemblance between the intelligence of foster children and their guardians, and Newman's converse findings concerning the considerable differences between the intelligence quotients of genetically identical twins who were reared apart, show clearly the important influence of environment as well as that of heredity upon intelligence as ordinarily measured. So too do the studies of Tallman and of Hermann and Hogben.

The latter group of studies revealed the fact that ordinary brothers or sisters (*i.e.*, those of different ages) are considerably less like one another, in their response to intelligence tests, than are brothers or sisters of the same age (nonidentical twins), despite the fact that the purely hereditary differences must in both kinds of cases be of the same average magnitude. The greater amount of difference between ordinary brothers or sisters[3] must be due merely to those environmental factors which differentiate the same family at different periods. In Burks' cases, the usual differences between certain chosen, measured features of home environment alone, occurring between families of the type she studied (mainly middle class), caused an average difference of about 6 points in the child's "Intelligence Quotient" (on a scale in which 100 is the "normal" I.Q.). This agrees as closely as could be expected with Newman's data. The latter indicate that those I.Q. differences between identical twins reared apart, which were caused by their having been reared apart, are

[3] The amount in question had, in these series of observations, nearly the same value as the amount by which the differences between nonidentical twins exceeded those between identical twins.

on the average of about the same magnitude (7± points) as those I.Q. differences between brothers or sisters, which were caused by their differences in heredity. To be sure, the hereditary differences between brothers or sisters average only about half as great as those between non-related individuals of a group. But in Newman's cases, as in Burks', the individuals compared were reared in what was in the main the same social class, so that the differences in environment were restricted also. Surely, the members of widely different social classes, such as Burks' mainly middle class people on the one hand, and white day laborers or Southern Negroes or Mexican immigrants, on the other hand, differ from one another, on the average, in respect to environmental advantages, by at least several times the average difference between two members of the same class. Hence we should expect I.Q. differences due to environmental dissimilarities between the children of the former and the latter classes to average at least 15 or 20 points. And this is what has actually been found.

The results, then, show us that there is no scientific basis for the conclusion that the socially lower classes, or technically less advanced races, really have a genetically inferior intellectual equipment, since the differences between their averages are, so far as our knowledge goes, to be accounted for fully by the known effects of environment. At the same time, we are brought to realize that, in a society having such glaring inequalities of environment as ours, our tests are very unreliable for the determination of individual genetic differences in intelligence, except in some cases where these differences are extreme or where essential likeness of both home and outer environment can be proved.

If the above is true of intelligence, it is even more true of temperamental traits, moral qualities, etc., since these are more responsive to conditioning than are purely intellectual characteristics. Thus, our social system creates unemployment, slums and graft as surely as it creates great industries, splendid churches and universities, and in the former process it creates what it itself brands as criminality. It is well known that certain slum districts constitute veritable factories for the conversion into criminals of those who happen to be born in them, whether their parents were of the criminal class or not, and, as Jack Black for instance has shown, an analysis of the lives of various individual criminals reveals to what an extent potentially valuable citizens may be turned to a life of habitual crime through the pressure of our social system. Under these circumstances it is society, not the individual, which is the real criminal, and which stands to be judged.

Naturally, the apologists for the still existing order would have us naïvely accept appearances at their face value. Their justification of the existing order requires this acceptance. This is bound to lead to a false genetic valuation of individuals, of classes and of races, so long as this system lasts. The apologists defend their position with the *a priori* argument that, in the social struggle, the better rise to the top. They neglect to show that success in modern economic competition depends on many other factors, besides innate endowment, and that to-day we have increasingly operative, instead, the principle of "to him that hath shall be given." But if we assume that inborn differences do play some rôle, the question is, what rôle? Are the characteristics which now lead men to rise, economically, those which are the most desirable, from a social point of view? It could at least as well be maintained that the dominant classes tend to have the genetic equipment which would be least desirable in a well-ordered social system, since they have been selected chiefly on the basis of preda-

tory, rather than truly constructive, behavior. A study of the lives of many eminent financiers confirms this. The "respectable" captain of industry, military leader or politician, and the successful gangster are psychologically not so far apart. The high-minded, the scrupulous, the idealistic, the generous and those who are too intelligent to wish to confine their interests to their personal monetary success, these are apt to be left behind in the present-day battle.

This brings us to consideration of another topic: What should be the eugenic goal? And here we meet with a third source through which eugenics is irremediably corrupted by our economic system. So long as present conditions continue, the ideology of the people must in the main be a reflection of that of the now dominant class, and the standards, the criteria of merit of the latter, will be accepted. Naturally, those in power will idealize their own characteristics, particularly those which brought them to dominance. In so far as they concerned themselves about eugenics, would not most of them believe in the production of bigger and better business men, who could see us through bigger and better depressions? There would also be room for various accessory gentry, such as sportsmen of the type who symbolized the predatory life, slapstick and slush artists to keep us harmlessly amused, and some safe and sane scientists to invent better poison gas and to harmonize science with useful superstition. And perhaps the most benighted elements could be cajoled or coerced into developing themselves into more callous slaves, who could work longer hours on a cheaper grade of beans. Not that this fantasy would ever be realized, for, as I have shown, eugenics under our social system can not work. Nor are the distinctions between these types truly genetic ones. But that would unquestionably be the direction in which the ideology of the dominant class would logically try to lead eugenics, if it could do so. Only the impending revolution in our economic system will bring us into a position where we can properly judge, from a truly social point of view, what characters are most worthy of a man, and what will best serve to carry the species onward to greater power and happiness in a united struggle against nature, and for the mutual betterment of all its members.

This elevation of our moral standards and reconstruction of our concept of values will be intimately associated with a change to realism in our whole philosophical outlook. There will therewith be cast aside the whole antiquated lot of organized deceptions, of mandates, mummeries and prohibitions, ostensibly dictated from without, which it has so long been to the advantage of "upper" classes to maintain among "lower," and which the so-called "eugenics" of the present day shamelessly condones. In this system of mores, a prominent part has hitherto been played by the superstitions and taboos enveloping and contaminating the whole subject of sex and reproduction. The last noisome cobwebs of these dogmas will necessarily be swept away along with the other débris. Thus the way will be prepared for the entry, into these so important activities of man, of more real and comprehensive research, openly directed at the most vital problems, and of ever more thoroughly rational practises, fearlessly applied in accordance with the results of the research. In this way a fourth and very serious block to eugenics in our present society will have been done away with. The possibilities of the future eugenics under these conditions are unlimited and inspiring.

Galton may perhaps be pardoned for not having realized that the day was soon coming when there would be fundamental economic and social changes, which would utterly alter the complexion of eugenic problems. But in our

day the writing on the wall is manifest, and they are fools who blind themselves to it. Let us rather prepare with open eyes to face our new problems. There is no use in arguing about the effects, in a hundred years or more, of the continued differential reproduction of different classes, when the very basis for the existence of these classes as such is in process of disintegration, and in place of the economic conditions imposed by the class struggle, entirely new conditions will be substituted. Similarly, the present disputes of eugenists about the fates of races will soon appear vain and beside the point, when the economic and social reasons for the existence of the differential fertility of races, as well as for race prejudices, will have disappeared with the general abolition of exploitation. True eugenics can then first come into its own and our science need no longer stand as a mockery. For then men, working in the spirit of cooperation, will attain the social vision to desire great ends, and to judge of what is a worthy end. Then first, with opportunities extended as equally as possible to all, will men be able to recognize the best human material for what it is, and garner it from all the great neglected tundras of humanity. Then, too, and not before, will the economic basis of society be such as to allow a truly social control over differential fertility.

That imminently impending society, ordering its processes consciously for the common good, assures every one economic plenty, takes away a large part of the burden of the children from the shoulders of the individual couple, and especially from the woman, and so makes it possible for them to decide by considerations of the interests of the future generations, and of the race as a whole, rather than of themselves, how many and what children to have. In this decision they will not be hampered by ancient animistic fears and prejudices. Thus it is up to us, if we want eugenics that functions, to work for it in the only way now practicable, by first turning our hand to help throw over the incubus of the old, outworn society.

Summary

It has been shown that eugenics under capitalism involves several serious contradictions:

(1) Under the capitalist system of economics, the fulfilling of the eminently social function of producing the next generation entails an excessively heavy individual burden which, added to the other economic stresses affecting most of the population, and especially the women, under this system, constitutes an often intolerable affliction. As a result, individual economic considerations rather than considerations of the genetic worth of the future generations must in the main govern human reproduction, in so far as the latter is voluntary at all, and eugenics must remain an idle dream.

(2) In order to justify the existence of the gross economic and social inequalities between classes, races and individuals, arising under our present economic system, it has been necessary for the apologists of this system to put forward the naïve doctrine that the economically dominant classes, races and individuals are genetically superior. Such scientific evidence as is available fails to support this contention, and shows that the differences in scores on so-called "intelligence tests," made by different races and classes, are, to the best of our knowledge, caused by the differences in environmental advantages which they received. On theoretical grounds, in fact, there is at least as much reason for supposing that the dominant classes represent a selection of socially inferior, as of socially superior genetic material. Thus capitalism leads to a false appraisal of the genetic worth of individuals, and of vast groups,

which results in entirely mistaken conceptions of eugenic needs.

(3) Our economic system, by exalting the acquisition of private profits, regardless of at what expense to others they were obtained, inculcates predatory rather than constructive ideals. In consequence, the ideal set of characteristics which most present-day eugenists and the population at large would set up as a eugenic goal, is far from the type which would be considered most desirable in a well-ordered society.

(4) It is advantageous for the dominant classes, under our present system, to foster a set of archaic superstitions and taboos, and these are directly antagonistic to rational, civilized practises regarding sex and reproduction.

Hence the impending radical changes in our economic order are prerequisite to a genuine, functioning eugenics.

THE GROWTH AND REPAIR OF NERVES

By Dr. CARL CASKEY SPEIDEL

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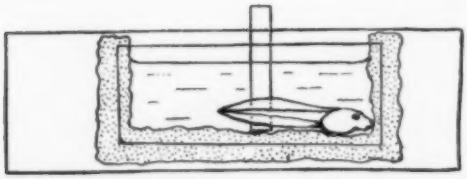
By a special technique I have found it possible for the first time to watch directly in the living organism two fundamental activities of nerve fibers. These are (1) the behavior of the actively moving tip of a single fiber as it grows toward the skin, and (2) the process of formation of the myelin sheath which later encases the fiber.

Small frog tadpoles are used and the observations are made on the developing nerves of sensation in the transparent tail fin. While the animal is kept lightly anesthetized, a region may be studied for a period of several hours. The tadpole is then replaced in pond water and the following day the same region and the same nerve fibers are again observed. In this manner the same individual fibers and sheath cells have been watched daily for as long as several months.

Experimentally, many actively growing nerve sprouts may be induced if the tip of the tail is sectioned and regeneration allowed for a few days. At the tip of each sprout is an enlargement, called a "growth cone." While at rest the growth cone is rounded and smooth in contour. In action, however, a number of extremely delicate processes are continually being extended and retracted, as if the immediate vicinity is being explored for a favorable route. The growth cone advances by a slow irregular flowing motion, spinning the nerve fiber behind it. It often displays a marked tendency to follow the fibrous processes of tissue cells which it meets.

A slight temporary obstruction in the path of the growth cone may cause a small thickening, or varicosity, to be left behind. A more formidable obstruction may lead to giant cones or to the formation of branches. Occasionally, when an insuperable obstacle is encountered, the growth cone is pinched off, and a new cone develops, which then starts its progress in a new direction.

Following the first, or pioneer, cone of growth come the second, third and later cones, each spinning a fiber of its own. As these usually adhere to the first fiber, a small nerve is thus formed. Ordinarily these grow out in the same direction, but a few cases have been seen showing that two growth cones may migrate along a nerve in exactly opposite directions at the same time, thus passing each other. Several varieties of nerve nets, or anastomoses, have also been observed in process of formation. Subjection of the entire animal to electrical stimulation causes no appreciable

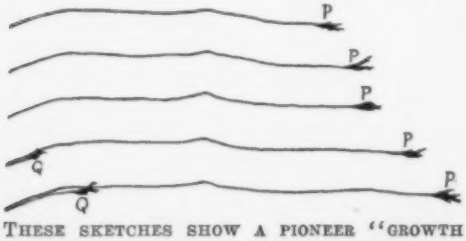


THIS DIAGRAM SHOWS THE TADPOLE IN THE OBSERVATION CHAMBER. THE ANIMAL IS KEPT LIGHTLY ANESTHETIZED. A REGION IN THE TRANSPARENT TAIL FIN IS SELECTED FOR MICROSCOPIC STUDY AND A MAP OF THE NERVES IS MADE. THE ANIMAL IS THEN REPLACED IN POND WATER AND THE FOLLOWING DAY THE SAME NERVES ARE FOUND AGAIN FOR STUDY, AND THE GROWTH CHANGES MARKED.

effect, either on the rate or direction of growth of active cones.

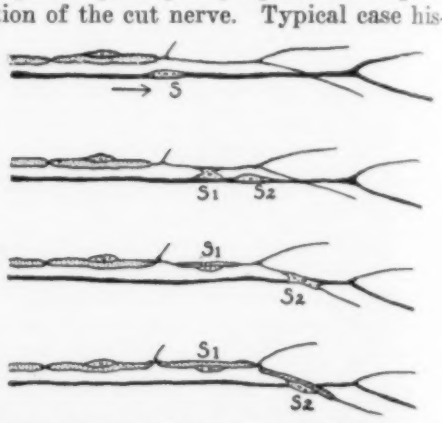
As nerve fibers become more mature, many acquire a sheath consisting of a fat-like substance called "myelin." The myelin sheath protects, nourishes and insulates nerve fibers. It is formed in segments, the first ones appearing near the nerve roots. I have watched the complete process of formation of more than 100 myelin segments. Each segment is formed through the cooperation of a "sheath cell" and a nerve fiber. Not all nerve fibers, however, are equally ripe for myelination. Those sprouts which emerge from a myelin sheath are especially ripe for myelin sheath encasement, as soon as a sheath cell arrives.

The myelin sheath is not very stable, and under conditions involving slight injury or irritation it degenerates. Many varieties of repair and readjustment of the myelin sheath have been watched. In all these a dominating rôle is played by the sheath cells. These cells exhibit exquisite sensitivity to near-by nerve injuries or abnormalities, and respond in an appropriate way to aid in the restoration of normal conditions. Under the proper stimuli they may travel in either direction along a fiber, or transfer from one nerve to another, or multiply.



THESE SKETCHES SHOW A PIONEER "GROWTH CONE" (P) ADVANCING TOWARD THE RIGHT SPINNING A NERVE FIBER BEHIND IT. THE SECOND GROWTH CONE (Q) FOLLOWS THE PATHWAY LAID DOWN BY THE FIRST. A PERIOD OF TWO HOURS IS REPRESENTED.

Detailed histories of the stumps of sectioned nerves reveal that several varieties of nerve regeneration may be distinguished. The exact phenomena of repair depend partly upon the composition of the cut nerve. Typical case histories have been obtained of the following: (1) section of small unmyelinated nerves (a) without anastomoses distal to the cut, (b) with anastomoses distal to the cut; (2) section of single isolated myelinated fibers; (3) section of small mixed nerves; (4) section of large nerves; (5) collateral regeneration.



THESE SKETCHES SHOW THE FORMATION OF THE FAT-LIKE "MYELIN SHEATH" ON A NERVE FIBER. A YOUNG SHEATH CELL (S) DIVIDES INTO TWO CELLS (S1 AND S2), EACH OF WHICH TRANSFERS TO THE NERVE FIBER TO BE ENSHEATHED. TWO NEW MYELIN SHEATH SEGMENTS ARE THEN FORMED UNDER THE INFLUENCE OF THESE CELLS. A PERIOD OF NEARLY A MONTH IS REPRESENTED.

The early changes associated with

nerve irritation have never been adequately observed and recorded in the literature. My observations indicate that profound disturbances immediately take place following injury. A myelin segment shows a pronounced fluid reaction with swelling, vacuole formation between myelin sheath and axis cylinder, and faintly visible currents within the axis cylinder. The myelin sheath exhibits a typical rippling and twisting activity. The axis cylinder assumes an irregular wavy course and its neurofibrillar structure becomes visible. The sheath cell nucleus becomes glassy, as though its contents were becoming liquefied, and it becomes less intimately applied to the myelin sheath. The vacuoles later disappear and the entire axone straightens, though it remains somewhat swollen for some time.

A segment appears to straighten by a "turgor reaction." If the irritation is not too great, the fiber may become normal again, the neurofibrillar structure becoming invisible. If, however, the fiber has been separated from its nerve cell or the irritation from another source is quite marked, typical degeneration follows with the myelin breaking up into ellipsoids and later into granules.

Recently I have succeeded in obtaining motion pictures of nerve fibers during the processes of growth and myelination, irritation and recovery, degeneration and repair. The pictures are taken at a rate such that, when projected on the screen, all movements are speeded 128 times (in some cases, only 32 times). Thus, the changes over a period of two hours may be exhibited by motion-picture film, which requires only one minute for its projection. Ciné-photomicrographs of this type beautifully reveal slow movements of the nerve fibers and the surrounding tissues that might otherwise escape notice.

Among the nerve activities which I have recorded by the motion-picture method are the following: the progress of the first, second and later growth cones of single nerve fibers; anastomosis formation; retraction; movements of fibroblasts and their effect on nerve growth cones; movements of sheath cells; mitoses of sheath cells; addition of new myelin segments at the end of a fiber; formation of a myelin segment at a node of Ranvier side-sprout; the actual, though slight, extension of the myelin sheath over a period of two hours; invasion of degenerating, regenerating and normal nerves by leucocytes; deformation of nerve fibers by tension of connective tissue cell processes; stimulation of nerve sprout formation by fibroblast mitosis; traumatic irritation of a proximal stump myelin segment and its recovery; the earliest changes associated with trophic (Wallerian) degeneration; irritation and recovery of a myelin segment following a near-by non-nervous wound.

THE PRESERVATION OF OBJECTS OF ANTIQUITY

By Dr. HERDMAN F. CLELAND

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If the works of the ancients are as much the heritage of future generations as they are of the scholars of the twentieth century, failure on the part of present-day archeologists to conserve this heritage would seem, to put it mildly, unfair. If this assumption is correct a discussion of means by which objects of antiquity can be preserved would seem to be pertinent; if not, it is without point.

In a recent article[1] the writer called attention to the failure of archeologists to take adequate measures to prevent the destruction of their archeological discoveries. The purpose of this paper is to discuss the problems of preservation.

Examples of Slow Disintegration in Nature

Under certain conditions objects are preserved by Nature for long periods without artificial aid. For example, when the covering of glacial drift was removed from the discovery vein[2] at Cobalt, Ontario, the workmen were astonished to find a broad band of untarnished silver which was so wide that they called it the "Silver Sidewalk." A similar discovery was made at Sudbury, Ontario,[3] where the surface of the ore shone like burnished copper when first uncovered. These surfaces were polished and later covered with drift by the last Great Ice Sheet which disappeared from Ontario possibly 20,000 or more years ago. During the Bronze Age in Sweden pictographs of historic events were chiseled on smooth, glaciated surfaces. Where overlain by a protective covering, they have been preserved to the present although they were made three or four thousand years ago. One such pictograph engraved on limestone was recently uncovered by Swedish archeologists but so rapid was the attack of the weather that it was found necessary to rebury it.

The remarkable mural paintings in the cave of Altamira[4] in Northwestern Spain are nearly as fresh as when painted thousands of years ago. The nearly perfect condition of the skin-like texture of the Hermes of Praxiteles at Olympia was due to the burial of the statue in wet mud where it lay for nearly two thousand years.

In the examples cited above water was present but was not in movement or, if so, the rate was so slow as to be negligible. As a consequence, there was no renewal of carbon-dioxide and oxygen, two gases which are active only when dissolved in water or in loose combination with water.

Wood may be preserved for centuries if it is immersed in water where it will be free from wood-destroying fungi and nearly free from bacteria. The only wooden objects made by Neolithic man on exhibition in museums are those which were buried in the mud at the bottom of lakes or in swamps. The poplar piles upon which the first Campanile in Venice was built in 900 A. D. were found to be strong enough, when reinforced, to support the weight

[1] "The Crime of Archeology," The Scientific Monthly, August, 1932.

[2] Letter from Professor A. P. Coleman.

[3] Letter from the late Dr. W. M. Miller.

[4] H. F. Cleland, "Weathering under Constant Conditions," *Science*, Vol. LVI, No. 1458, Dec. 8, 1922, pages 660–661.

of the tower which was rebuilt in 1905–11. It is evident from the above that water does not necessarily hasten decay, but is a passive agent in some cases and possibly a preservative in others.

It is a matter of common observation that where the air is dry, where there are slight changes in temperature and where light is excluded, objects disintegrate slowly. Finds in graves in Egypt, Peru, and other arid countries afford many examples. Elaborate ornaments, centuries old, made of feathers, as well as quantities of cloth, have been found in Peru. An interesting example of preservation under such conditions is to be seen in a piece of linen cloth decorated with two bands of tapestry weaving in wool, from Egypt, but now in the British Museum, which was made about the fourth century of our era. Other pieces of cloth from the same region date as far back as the sixteenth century B. C. Wooden objects from some Egyptian tombs seem nearly as fresh as when buried, and the colors are still bright. The reasons for this preservation, as already pointed out, are evidently (1) the fact that there was no moisture in which the carbon dioxide and oxygen gases could be dissolved (these gases are inert when dry), (2) the constant temperature and (3) the absence of light.

There are four other points which should be considered. (1) Great pressure may accomplish nothing more than to prevent the movement of water, and, except when columns are made of rocks which are under strain, may be disregarded. (2) When a rock is many times alternately wet and dried the effect is to cause it to crumble. This is because practically all types of rocks contain small amounts of soluble matter that can be leached out by water. When this soluble matter forms crystals within the rock, the growth of the crystals exerts a strong wedging action which often results in spalling the surface. (3) The repeated expansion of stone by daily changes in temperature loosens the grains of the rock and causes it to crumble. These last two agents of the weather are probably the most important in the Mediterranean Basin. (4) The effect of light on colors and on some substances is well known. For example, the mineral realgar (AsS) changes to orpiment (As_2S) when exposed to light for a few years, and the color of some stones, such as rose quartz, fades.

The preservation of the original substance of calcium phosphate shells of Cambrian Age for some 500,000,000 years and of the nacreous luster of calcium carbonate shells in Cretaceous formations for 100,000,000 years or more show that under certain conditions objects are practically imperishable.

Suggestions

Little difficulty will be encountered in preserving for many centuries, possibly for thousands of years, objects which can be kept under cover. If museums are properly constructed and are equipped with apparatus which will keep the air at a uniform temperature and nearly free from moisture, and if corroding gases and bright sunlight are excluded, there seems little doubt but that objects contained in them will remain in approximately their original condition for many centuries.

This fact is well illustrated by the condition of objects of many materials in the ancient Japanese treasure house of Shoso-in[5] where they have been stored for nearly 1200 years. The story of this unique and remarkable building is of great interest in this discussion. It is briefly as follows: Upon the death of the emperor Shomu in 756 A. D., the empress gave as a memorial to her husband all of the imperial treasures and the personal belongings of her husband. These were stored in the Todajii monastery

[5] Asa Matsuoka, "Shoso-in-Ancient treasure House." Pub. by Japan Society, New York, 1930.

which, when enlarged to accommodate the memorial, was 108 by 48 feet and 39 feet high. The building is supported on pillars which raise it 9 feet above the ground. The walls are made of triangularly fashioned timbers, probably of cypress, held together by wooden pins. There are no windows and only three doors. Consequently, no light enters the building. Because of the absence of light the original colors of the objects are as perfectly preserved as if recently installed. The building is self-ventilating. In the dry season the timbers of the walls and the boards of the floor shrink and air enters; in the wet season the timbers swell and moist air is excluded.

The building is now opened to an invited group of visitors once a year, but in the past it had remained unopened for as long as one hundred years, and the shortest period previous to 1872 was thirty years. In 1892 the treasures were taken from the chests in which they had been kept for more than 1100 years and placed in glass cases.

In this paper we are concerned chiefly with the preservation of materials. Chests, tables, and desks of wood, screens covered with textile fabrics, paper, and feathers, incense, medicines, documents of white linen paper, ancient arms and armor, ivory objects, bronze mirrors and coins, "shark-skin," leather shoes, leather saddle trappings, and silk and cotton cloth are all in a remarkable state of preservation. Sword blades, halberds and spears shine as though they were placed there yesterday.

Such is the condition of the treasures of Shoso-in after nearly twelve centuries. They demonstrate that with intelligent care objects in buildings may have a long life.

The Japanese have also recently[6] called science to their aid in an attempt to preserve for at least 10,000 years the names of the victims of the Japanese earthquake of 1923. Names of the dead were written in China (carbon) ink on a fine grade of paper. This record was then inserted in bottles made of fused quartz. The air was exhausted from the bottles and the vacuum thus created filled with argon gas. The quartz bottles were wrapped in asbestos and sealed in a lead container which in turn was placed in a fireproof carborundum cylinder. Argon gas was probably used because of its inertness and because, being denser than nitrogen, it has a slower rate of diffusion. Although these records may be preserved for thousands of years they can not be seen.

It is evident that with proper care smaller objects can be saved from decomposition and at the same time be available for study at reasonable expense. But the vast ruins of temples and other works of antiquity present a much more difficult problem, and one which has not yet been solved.

From the examples cited it is clear that either water must be excluded from objects, or, if present, it must be sealed in so that it can not be renewed. The need, therefore, is for a durable, transparent, waterproofing substance. Such a substance has not yet been invented. Coating with paraffine has proved to be nearly useless, as the experience with the Egyptian obelisk in Central Park, New York City, clearly shows. It is for water-proofing substances that the research chemist should be urged to labor.[7]

There is one agent of the weather

[6] *Illustrated London News*, September 5, 1931.

[7] Dr. C. S. Piggot in a letter, received since this article was in the hands of the printer, states that he has experimented with tetramethyl-orthosilicate as a preservative for stone. The substance penetrates into the stone for a considerable distance, hydrolyzes there, producing ethyl alcohol which evaporates out, and deposits SiO_2 in the pores. Repeated treatments tend to fill the interstices with SiO_2, thus rendering the stone less porous and somewhat tougher at the surface. It is a liquid, safe to handle, and easy to apply. The stone must be dry.

which, in the present state of our knowledge, seems unconquerable: that is, disintegration resulting from changes in daily temperature. This agent will disrupt rocks which are exposed to the heat of the sun which expands them, and to the cool of the night which causes them to contract.

From the examples cited above, it seems clear that if objects of antiquity are to be kept from disintegration and at the same time are to be available for study they must either be kept under cover or protected by some artificial coating which will, in effect, accomplish the same result as enclosure in a building. For the larger ruins, such as those of Delphi, Olympia, and Delos, where the expense of a cover is prohibitive, the only alternative at present seems to be to rebury them after they have been carefully studied and illustrated. If and when transparent stone preservatives are discovered they can be reexcavated.

ON FRANCIS GALTON'S CONTRIBUTION TO THE PSYCHOLOGY OF RELIGION

By Dr. ERNEST L. TALBERT
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In his "History of Psychology," Professor Pillsbury writes a succinct and appreciative account of Francis Galton's work in general psychology upon imagery, association, sensory tests, instinct and the quantitative study of mental traits.[1] Professor Pillsbury does not mention Galton's constant reference to the mental processes of religious persons.

The second volume of Karl Pearson's "The Life, Letters, and Labours of Francis Galton" reveals a consuming interest in religion, its nature and its function. It is well known that Galton's version of religion had its setting in the theory of evolution, especially as understood by Darwin, and the intellectual climate of the Victorian era. For him the object of religious emotion is the process of life, operating by natural selection in its earlier stages, supplemented by artificial selection in its later ones. Of this cosmos, picturable in imagination as a unitary being, the individual may be looked upon as a cell, more or less unconscious of his full relation to the whole, just as the individual cells of the body serve organic functions without knowing why and how. It is possible for man to become increasingly conscious emotionally and intellectually of his ancestry and his posterity. It is his high privilege to aid the beneficent trends, warned by the results of disastrous and wasteful evolution during the pre-human stages. Mankind may in part determine its own future.[2] "Darwin had taught evolution as a scientific doctrine; Galton proposed that this new knowledge should be applied to racial and social problems, and that understanding of, sympathy with and aid in the progress of the general evolution of living forms should be accepted as religious duties."[3]

In order to realize the ends of evolution a change of values and of the method of educating youth is called for. Galton, like Huxley, is impatient of the

[1] Pillsbury, "History of Psychology," pp. 201–203, New York, Norton, 1929.

[2] Galton, "Inquiries into Human Faculty," pp. 194–198, New York, Dutton, 1928; "Hereditary Genius," p. 376, New York, Appleton, 1887.

[3] Pearson, "The Life, Letters and Labours of Francis Galton," Vol. II, p. 261, Cambridge University Press, 1924.

sectarian absolutism of his day. Mankind inherits the slavish and gregarious instincts of oxen and of other lower forms.[4] Conscience and intuitive principles date from past necessities and are no certain guide for the variables arising in the present. The hold of theological doctrine is imputed to habits and sentiments fixed in childhood. Intelligence and unfettered inquiry, recognized as essential in science, have not been applied to the phenomena of traditional religion.[5] Religious attitudes should be based upon science and its ministry to human welfare.

The time is ripe for methodical investigation of assertions which religious persons make about the nature of inspiration, existence of spirits and answer to prayer. The subjective aftermath of prayer is undoubted, its objective implications not so certain. The conclusive test is experimental. Galton insists upon applying statistical methods to the objective efficiency of prayer. Royalty are prayed for often, yet their longevity is less than that of other groups not designated in ecclesiastical ceremonial.[6]

Persons other than the religious are subject to idiosyncratic images and other unique mental happenings. In ages of miracle and faith these experiences are rated high in significance. In later centuries those to whom like experiences come attach no importance to them, since the community does not.[7] They conceal them, at least until solicited by questionnaires.

The visions and other mental states of religionists should be estimated in the light of known mechanisms of mind. Galton stresses the presence and activity of clusters of emotionalized associations not ordinarily brought into conscious focus. These usually subconscious contents can be drawn from the "antechamber of consciousness." They are attended to by the religious man, and their revival becomes automatic. The term "dividuality" is used by Galton to describe an experience in which subjective processes are taken to be objective by the dissociated self.

Divines are more sickly than members of other professional groups.[8] Excessive piety is sometimes related to sexual disorganization.[9] On the basis of limited biographical data Galton propounds a theory that "the chief peculiarity of the moral nature of the pious man is its conscious instability."[10]

Galton was essentially a frontiersman in science. His findings and conclusions have been subjected to scrutiny by subsequent students of religion. Some of his ideas have been rejected, others have entered into the body of anonymous material which every science contains. His views are cited not to defend their finality but to support the conviction that his pioneering in this field deserves recognition.

[4] "Inquiries into Human Faculty," pp. 55–56.

[5] *Ibid.*, pp. 149–152.

[6] "Statistical Inquiries into the Efficiency of Prayer," *Fortnightly*, August, 1872; other references cited by Pearson, *op. cit.*, pp. 115–117.

[7] "Inquiries into Human Faculty," pp. 127–128.

[8] "Hereditary Genius," p. 265.

[9] "Inquiries into Human Faculty," p. 46.

[10] "Hereditary Genius," pp. 281–282.

THE DUDLEY OBSERVATORY CONTROVERSY

By WILLIAM K. PRENTICE

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THE awakening among non-professional people in America, about the middle of the nineteenth century, of an interest in the advancement of knowledge, and of a desire that Americans have a place with the scientists of the older world in scientific discovery, is an interesting episode in the development of this country. Long before that time colleges had been founded here, chiefly for the purpose of training candidates for the professions. Some learned societies had been formed, such as The American Philosophical Society at Philadelphia in 1743 and The Academy of Arts and Sciences at Boston and Cambridge in 1780. During our revolution and afterwards, some of the leaders of the nation were fairly familiar with the philosophic thought and political theories of England and of France. But when, in 1842, an English astronomer was told that there had been organized in Cincinnati "an astronomical society of more than three hundred members from every rank, grade and profession in life, from the hard-working mechanic to the retired merchant, from the butcher in his stall to the professor in his gown," and that these had contributed funds to equip an observatory in their city with instruments of the best quality, the Englishman exclaimed: "This is a most curious, wonderful affair! A democratic astronomical society!" Something was happening then in the new world, which had not happened before, at least since the golden age of Athens.

At that time Americans were removed by only a few generations from the conditions of actual pioneers who hewed their homes from a wilderness and secured a livelihood by unremitting toil. The republic which they had founded was scarcely more than half a century old. Yet life, at least along the Atlantic coast, had become settled, and for many prosperous; many had now some leisure to devote to other things than the struggle to exist.

No branch of science appealed more strongly to these Americans than astronomy. It revealed to them something of the "wonders of science," and brought them directly into contact with the universe beyond the earth. Besides, this particular science had an application to practical matters which any one could appreciate, the determination of standards of time, the location of places by latitude and longitude, map-making and navigation. One of the pioneers of astronomy in this country was O. M. Mitchel, a graduate of West Point in the class of 1829, and from 1836 to 1845 professor of mathematics and engineering in Cincinnati College. In consequence of the interest aroused by popular lectures given by him in the winter of 1841–2 under the auspices of the Cincinnati Society for the Diffusion of Useful Knowledge, he organized the Cincinnati Astronomical Society, raised more than fourteen thousand dollars by private subscriptions in cash, due bills, work and materials, secured a gift of about four acres of land, built an observatory and installed in it a telescope made for it in Munich. When this telescope was mounted early in 1845 it was, with the single exception of the equatorial at Pultowa in Russia, the best refracting telescope in the world.

At Albany in 1851, at a meeting of ladies and gentlemen in a private house,

plans were discussed for establishing in the state capital a university of which an astronomical observatory should be a part. A letter from Professor Mitchel of Cincinnati on the value of astronomy was read at this meeting, and Professor Agassiz of Harvard made an address on the proposed University of Albany. It was decided to begin at once with the observatory. When subscriptions were invited $25,000 was raised in a short time, and several acres of land, suitable for an observatory, were given. Early in 1852 a corporation was formed, under the name of The Dudley Observatory and under the control of a board of fifteen trustees. The building was completed in the following year, and it was expected that Professor Mitchel would take immediate charge of securing the necessary equipment and staff; but since he was not able, at that time, to do this, the building remained for two or three years unoccupied.

It was no small ambition which inspired these citizens of Albany. They took no small interest in the intellectual development of the country. The discussion of plans for a National American University in their city continued, and a bill to support such an institution was presented to the state legislature in the winter of 1852–53. Evidently it seemed to many that the capital of New York State was as natural and proper a place for a National University as the Federal capital at Washington. These plans were not carried out. The Dudley Observatory, however, The Albany Law School and The Albany Medical School were founded. At the "inauguration" of the observatory, on August 28, 1856, Dr. Gould, its director, said: "The aspirations of our countrymen for some high educational seminary in the land, that shall receive American youth where the colleges leave them, and afford the same facilities for the highest culture in specialties, that the colleges offer for the general acquisition of information, refinement and taste; . . . and which shall supply to our own young men the combined sources of knowledge, which they have hitherto been compelled to seek on the other side of the ocean, have within a few years found expression in various places; but nowhere has the effort to bring the aspirations to fulfilment been so vigorous as in this city of Albany."

In midsummer, 1855, at the meeting in Providence of the American Association for the Advancement of Science, the affairs of the Dudley Observatory were discussed. Soon afterwards an arrangement was made by which the U. S. Coast Survey was to take for a time the direction and control of the observatory. The trustees, on September 3, 1855, appointed a scientific council, consisting of A. D. Bache, at that time superintendent of the U. S. Coast Survey and regent of the Smithsonian Institution; Joseph Henry, formerly a professor at Princeton and at that time first secretary and director of the Smithsonian; Benjamin Peirce, then professor of astronomy and mathematics at Harvard and in charge of the longitude department of the Coast Survey; and Dr. B. A. Gould, Jr., the founder and editor of the *Astronomical Journal*. Dr. Gould was sent abroad to procure instruments. In addition to her former contributions Mrs. Dudley gave $14,500 for a heliometer, and later $50,000 more towards an endowment. Two gentlemen, whose names were not given, assumed the responsibility for a meridian circle "to be provided without any limitation of expense." Another subscribed $1,000 for a sidereal clock, which was afterwards known by his name. All these contributors were private citizens of Albany.

So the beginnings of the Dudley Observatory were most promising and creditable to its promoters. In a little more than two years the resident director had

been forcibly expelled from the property by the trustees, the scientific council had been discharged and the operation of the observatory had practically stopped.

The Dudley Observatory controversy of 1858 had, at the time, a very wide publicity. The most influential member of the board of trustees, and from March 2, 1858, its president, was the president of one of the prominent banks of Albany and a man of very considerable influence. He and the secretary of the board, who from the beginning had been the most active promoter of the enterprise, took great pride in the observatory, and felt that to them in chief belonged the credit of its establishment. They wished the people of Albany to visit it, to be impressed by it, to wonder at it, and its instruments, and the mysterious work which was being carried on there. They wished, of course, to be regarded as patrons of science. They did not know much—perhaps they did not know anything—about astronomy or the necessary requirements of a scientific observatory. Yet they felt themselves competent to decide, contrary to the judgment of the director and the scientific council, on matters relating, for example, to the construction of the buildings and the mounting of the instruments. Apparently they believed that a scientific observatory could and should be managed as a bank was managed. The secretary of the board visited the observatory frequently, and gave orders personally on the authority of the trustees. The director, Dr. Gould, in his reply to the attacks of the trustees (p. 5) says: "I had for a long time had cause for complaint against one Trustee, whose constant interference with my plans, and whose foolish and lavish expenditure of money had occasioned me much annoyance and anxiety; and had led to earnest, though friendly appeals on my part, in behalf of the interests of the Observatory." The director and the scientific council refused to accept the direction of the trustees in matters which concerned the construction and operation of the observatory and the appointment of its personnel. They asserted that they had accepted the responsibility for the conduct of the observatory on the understanding that the final authority in such matters had been delegated to them by the trustees, and that on this understanding most of the money for the observatory itself, its instruments and its endowment had been contributed. This was all true. On the other hand, the trustees, in a resolution of January 9, 1858, asserted "that the Board of Trustees of the Dudley Observatory, as legal guardians of the Institution entrusted to their care, must claim an undivided and entire control over its property, the appointment of its officers and its general policy." According to the articles of incorporation, this was also true, unless the authority for the management of the observatory had been properly delegated to the scientific council. Thus there arose a clash of authority, and a determination on the part of some of the trustees to get rid of Dr. Gould.

The first definite expression of antagonism arose late in the year 1857 over the efforts made to secure the appointment of Dr. C. H. F. Peters to a position on the staff of the observatory. Dr. Peters was a native of Schleswig, a mathematician of considerable ability, who had found employment in the geodetic survey of the Kingdom of Naples, and later in Sicily and Constantinople, but no permanent situation. He came to America and was received by Dr. Gould, whose acquaintance he had made in Europe, into his house as a guest. Through Dr. Gould's efforts he secured a subordinate position as a computer in the U. S. Coast Survey. At his own request, he was sent to Albany to continue

his work for the Coast Survey there, to assist Dr. Gould privately, receiving for this service compensation from Dr. Gould personally, and to use, voluntarily, the "comet finder" of the observatory. Because of his failure to complete his work for the Coast Survey, however, in the summer of 1857 he was ordered to Cambridge to be under the immediate supervision of Professor Peirce, who had general charge of these computations. He then promptly resigned his position in the Coast Survey. Meanwhile he had won the support of some influential trustees, who evidently believed he would be more amenable than Dr. Gould. These trustees urged Dr. Gould to appoint Dr. Peters as his assistant at the observatory, but Dr. Gould, supported by the rest of the scientific council, refused. This led to a series of anonymous attacks upon Dr. Gould in the newspapers. A petition was circulated among prominent citizens of Albany and signed by a good many, urging the trustees to appoint Dr. Peters to the staff of the observatory. It was later proved, by the published testimony of one of the signers, that some, perhaps most of these signatures had been obtained by a misrepresentation of the facts. Acting upon this petition a majority of the trustees passed a resolution on January 9, 1858, appointing Dr. Peters as observer at the Dudley Observatory, in spite of the earnest opposition of several members of the board. The majority trustees, in their "Statement" issued later on, spoke of him as "a practical astronomer, a devoted lover of his science, and a faithful and diligent Observer." One of their number said: "To me he bears the genuine marks of a truthful, studious, laborious and eminent Scientist." Another called him "a ripe scholar, an accomplished astronomer." Dr. Gould and the scientific council had found Dr. Peters untrustworthy. The majority trustees seem to have regarded their action of January 9 as a dismissal of Dr. Gould and an appointment of Dr. Peters in his place. However, ten days later, the trustees reversed their decision, confirmed the "informal" election of the scientific council and resolved "that the Observatory, under the supervision of the Scientific Council, shall be immediately placed in operation, and in charge of Dr. B. A. Gould, Jr., and his assistants, in the employ and pay of the U. S. Coast Survey." Dr. Peters was thus eliminated, and soon afterwards secured a position as astronomer at Hamilton College. But this was by no means the end of the controversy. On the second of March, 1858, the board of trustees, consisting normally of fifteen, elected a new president, and appointed an executive committee of nine with full power, subject of course to the approval of the board. But, as these nine constituted a safe majority of the board, their action as an executive committee was practically final. Thus the minority members of the board were practically eliminated. On May 22 the majority trustees passed resolutions condemning those in charge of the observatory for lack of courtesy to the trustees, and demanding, among other things, free access for the trustees and their friends to the observatory at all times. On June 4 the trustees passed another resolution, asserting "want of harmony" between the administration of the observatory and the trustees. This resolution was communicated to the scientific council, which then asked for definite information from the board; but information was refused. On June 25, 1858, the president read to the board a "Manifesto," which consisted of a bitter and vicious attack on Dr. Gould, and this manifesto was adopted by the board, and published as a "speech" in the newspapers and also as a pamphlet. The board also passed at this time a resolution that their vote of

June 4 involved the immediate withdrawal of Dr. Gould as director, and another resolution that the board would no longer recognize Dr. Gould as a member of the scientific council. The other members of the council arrived in Albany on June 27 and requested a meeting with the board of trustees. This request was declined. The council then asked for evidence supporting the "Manifesto." This was also refused by the board, on the ground that the decision of the board was final. The council then investigated all the charges against Dr. Gould, issued to the trustees a protest against the proceedings of the board, and resolved to take personal charge of the observatory for a time, each of the three members of the council, excepting Dr. Gould, taking over the management personally for a month in turn. The result of this was that the board of trustees on July 3 passed a resolution dissolving all connection with the scientific council. Consequently, on July 10, the scientific council published their "Defence of Dr. Gould," of which three editions were issued, completely exonerating the director. This "Defence" aroused great indignation against the trustees. A large meeting of citizens was held which, after some discussion, voted unanimously in condemnation of the trustees, and appointed a committee of twelve to draft resolutions expressing the opinion of the meeting. The trustees replied by publishing a pamphlet of 173 pages, entitled: "The Dudley Observatory and the Scientific Council: Statement of the Trustees." Twenty-five thousand copies of this pamphlet were issued and sent throughout the country. It was a restatement and elaboration of the "Manifesto" issued in the preceding June. It was composed with considerable skill, and must have appeared most plausible to those who knew nothing of the actual facts. It assailed in detail the entire management of the observatory during Dr. Gould's administration, his ability and standing as an astronomer, his character and his integrity. But it was completely refuted by Dr. Gould's "Reply to the Statement of the Trustees," which was published in January, 1859, shortly after Dr. Gould had been forcibly ejected from the observatory. In 366 pages the director disproved every accusation of the majority trustees, repelled every insinuation and showed that most of what was produced in the "Statement" as evidence consisted of misstatements, incomplete, inaccurate and misleading quotations and actual falsifications.

Altogether, the published papers and documents relating to this controversy amount to at least 706 printed pages. The most significant are parts of the "Address to the Citizens of Albany," drafted by the committee of twelve appointed for this purpose at the public meeting held on July 13, 1858, to which allusion has been made. In this "Address" it is stated that the resolutions passed by the trustees on May 22 "were of a most extraordinary character; they proposed, in effect, to open the grounds of the Observatory to the public, as a park, or promenade; to convert the Observatory building into a public museum of curiosities; to place duplicate keys at the command of any of the trustees, so as to give them access, 'at any and all hours,' 'with or without friends,' 'to the Observatory and all its rooms.'" With regard to the "Manifesto" of June 25th, this committee asserted that "there does not exist, and there never has existed, the slightest foundation in truth . . . for any of the complaints, charges or accusations against Dr. Gould, contained in this paper. . . . Taking them together or taking them one by one . . . we pronounce them, one and all, merely, utterly and nakedly scandalous, without

a shadow of truth, reason or justice, to stand upon." Finally, in their closing paragraph, the committee says: "It is possible that the Dudley Observatory may be saved, if the Board of Trustees would close with the proposition understood to be made, or about to be made, to them by the donors, to submit the whole subject of its difficulties to the arbitrament of several very eminent and unexceptionable gentlemen, as named in that proposition. Otherwise, we know of nothing now that can restore it to public favor, and to any possible usefulness, but the prompt and voluntary withdrawal of such of the Trustees as shall be found unwilling, after the developments and exposures which have been made, to cooperate with Professor Henry, Professor Bache, Professor Peirce and Dr. Gould, in a manner to enable them to prosecute and perform their proper duties to the Observatory, the donors and the cause of the science. This, or a thorough revision and alteration of its very exceptionable Charter by the Legislature, seems to us to afford the only remaining grounds of hope for the Observatory."

Thus the Dudley Observatory was shipwrecked on that rock, which has been and still is an obstacle to the success and progress of institutions of learning in this country, namely, the exercise by a board of trustees of the authority, generally conferred upon them by the charter, to control directly the administration of the institution, and to appoint or discharge its personnel. It should not confuse the issue involved that this particular board of trustees, when their actions were challenged and criticized, resorted to personal attacks upon the director which were not supported by the facts. The Dudley Observatory controversy shows in one very extreme instance that trustees chosen to administer the finances of an institution are not ordinarily competent to decide the scientific questions which necessarily arise in its operation. The gist of the matter is correctly stated in the concluding paragraph of the "Address" of the committee of twelve quoted above. If the articles of incorporation of such institutions commonly give the ultimate authority in scientific matters to such trustees, these articles of incorporation should be changed. The awakening of interest in scholarship and science among the people who have no great training or experience in scholarship is wholly admirable and has been and is productive of great benefit to this country as a whole. But when this interest leads to the control of institutions of learning by persons who have not far more than an ordinary knowledge of scholarship, then this public interest is also a source of harm.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

HOUSEHOLD HEALTH HAZARDS

By Dr. YANDELL HENDERSON

PROFESSOR OF APPLIED PHYSIOLOGY, YALE UNIVERSITY

I AM going to talk over with you some of the dangers that we are all exposed to nowadays. We all realize the hazards to life and health that the automobile has introduced, for many people are killed even in trying to cross the street. But the dangers that we are going to consider now are not so well known. They are quite largely hazards to health and dangers to life that occur in our homes.

Nearly all these dangers have developed rather recently. They are nearly all due to advances in science. You know that the advances in medical science have greatly decreased the deaths and illness from infectious diseases. The applications of medical science have made life much healthier and the average life much longer. A generation ago diseases like typhoid fever and diphtheria caused a heavy death rate, while now in a town or city with a good health department a year may go by with few or no deaths from these diseases. To a large extent this advance has been made by the health departments of our cities, our states and the national government. It is the fashion just now to criticize the government for costing so much and for requiring high taxes to support it. But the truth is that the service that the national, state and local governments render us simply in protecting our health is worth every cent we ever pay in taxes. It would be a disaster, if the effort to decrease the expenses of our various governments resulted in crippling the public health services.

We know that the police protect our property and our lives from criminals; that the fire departments protect our homes from fire; and that the U. S. Army and Navy protect us from foreign enemies. But we seldom think of the protection that the government gives us in regard to the food that we eat and that it should give us in regard to certain hazards to which our homes are now exposed. The most important protection of this sort is that afforded by the federal pure food law, and similar laws in the states together with the arrangements that the government maintains to see that the pure food laws are obeyed. The Agricultural Experiment Stations in many states are every day analyzing samples of foods that are being sold on the open market and these results are published in the reports of these stations. Impure foods are confiscated and destroyed. You can get one of these reports by writing to your state government.

Before the pure food law was passed any food producer could sell nearly anything that he could persuade the public to buy, no matter how much his product was misrepresented. I remember some strawberry jam that was highly advertised as a superior product, but it was found to consist of apple butter sweetened with corn syrup, flavored with a synthetic chemical flavoring, colored with a coal-tar dye, with artificial

wooden seeds scattered through the jar. The one thing that that jam did not contain was strawberries. It was like the wooden nutmegs that were once said to have been manufactured in Connecticut, where I live. I doubt the story about wooden nutmegs, but until the pure food law was enacted there were sausages made that had almost no sausage meat in them. And then there was the so-called embalmed beef that was alleged to have been supplied by some of the big packing houses to feed the soldiers in the Spanish War. I don't know whether Theodore Roosevelt, when he led the Rough Riders in Cuba back in 1898, ever ate any of that embalmed beef, for our soldiers in that war had very little to eat of any sort. But when he became President one of the measures he got Congress to pass was the pure food law. There was, of course, great opposition from some food producers on the ground of bureaucracy and interference with freedom of trade. But the law was passed and it has really been almost as valuable to producers and merchants as it has to consumers. It has not only prevented many cases of food poisoning and swindling by sale of inferior products; but it has also greatly increased the sale of all sorts of canned goods and foods in packages. So long as there was doubt of the purity and healthfulness of such foods people hesitated to buy them. Now they are sold in immense quantities, for every package of breakfast food, every can of vegetables and every bottle of pickle on the market is now subject to the supervision of the federal and state governments. All food products are required to be free from adulteration, and the label on the can or package must tell the truth about the contents.

Another big step to protect the American home was taken three or four years ago when Congress passed and President Coolidge signed a law called The Corrosive Poisons Act. This act requires a warning label on various chemicals and cleaning fluids that are used in nearly every home. One of these substances is soda lye that is used to clean the kitchen sink. Every now and then a little child got hold of the can and swallowed some of its contents. The result was fearful injury, lasting sometimes throughout life, even if the child was not killed immediately. All such substances must now bear a warning label, and many accidents are thus prevented.

But this is not yet enough. There are still many substances that are sold and that are very useful but which carry dangers into our homes. And against these substances, some of which are very poisonous, there are as yet no protective measures and no requirement for a warning on the label. A couple of years ago many cases of illness, and perhaps some deaths occurred in hotels, and some may have occurred also in private homes, where the forks and spoons were cleaned with a silver polish containing the deadly poison potassium cyanide. A few grains of this polish between the prongs of a fork were enough to cause serious illness. There was no warning on the label of that silver polish. It has been withdrawn from sale. But it was an excellent polish, and there is nothing now to prevent another manufacturer from putting out a similar polish containing potassium cyanide under a fancy name.

There is now on the market a powder for cockroaches. It contains sodium fluoride and has killed several people who took it by mistake. It is sold in a package that looks like that of salts. It has no warning on the label.

The largest group of poisonous substances that now go into our homes without any warning of their dangers are various volatile liquids and new chemical substances that are each year

invented by chemists, and put on the market and sold to the public, before any test has been made as to whether they are poisonous or not. For such substances there is as yet no requirement that the label shall give warning of danger. One of these substances that is very useful for cleaning purposes is carbon tetrachloride. Now let me say at once that carbon tetrachloride has certainly saved more lives and health than it has destroyed or injured. It is very much safer to remove grease spots with this liquid than it is with gasoline or naphtha, for carbon tetrachloride does not catch fire. It will not burn; but many a woman has been badly or even fatally burned by gasoline. On the other hand, carbon tetrachloride has a vapor that is distinctly poisonous. The substance should be used only in well-aired places so that the user does not inhale the fumes. In Switzerland carbon tetrachloride has been used as the solvent for a floor wax in a school. It caused serious illness. There is now no law or regulation in America to prevent carbon tetrachloride and similar new substances being used in floor polish. It can cause serious illness in children playing on a floor polished with such substances. There is no requirement now for a warning in the label on the can. It is not sold to the general public as carbon tetrachloride but under a fancy name. The next time you buy a bottle or can of cleaning fluid ask what it really is. In fact, when you buy any chemical for use in your home always find out what the constituents really are.

I do not want to give you the impression that American manufacturers wish to poison those who buy their products. They do not. They are humane men, and deaths or illness caused by their products react against selling their goods. The harm comes from the fact that when a new substance is invented by chemists and is found to be useful for some purpose, it is manufactured and sold without any investigation of whether its use involves hazards to health and life. Chemists had been looking for a substance that would prevent automobile engines from knocking; that is, from premature explosions in the cylinders and loss of power. At last an effective substance was found to be tetraethyl lead; and the manufacturers were about to distribute it all over the country to be added to gasoline at filling stations. Fortunately, scientific men who knew that tetraethyl lead is a powerful poison were able to warn the manufacturers in time. As a result the substance, instead of being distributed in concentrated form, is now mixed with the gasoline at petroleum refineries and distributed as "ethyl gas," which is relatively safe. Warnings are also put on the pumps at filling stations. There have been few or no cases of poisoning since these precautions were put into effect; but without these precautions there would almost certainly have been hundreds of cases of poisoning.

Another substance, methyl chloride, has, however, caused a number of deaths. This liquid or gas is used in some makes of automatic refrigerators. These refrigerators are certainly a great convenience as compared with the old-fashioned ice refrigerators. They are also quite safe if they are made in single units. Methyl chloride in a single unit refrigerator is perhaps safer even than most of the other gases that are used. But, unfortunately and unwisely, multiple systems of refrigerators were allowed to be installed in big apartment houses in some cities. Such an installation involves a big storage tank or cylinder of the refrigerant in the basement connected to many refrigerators in the various apartments. If any one of the refrigerators in any one

of the apartments develops a leak the whole of this large amount of gas from the cylinder and from all the other refrigerators in the building escapes into that one apartment. This occurred in some apartment houses in Chicago and caused a number of deaths a year or two ago. Large multiple refrigerator systems are dangerous. Single units are safe.

I could easily tell of other examples of the household hazards that modern scientific conveniences have introduced into our homes. The electric light fixtures in a bathroom should always be so arranged that no one can make contact with a live wire with one hand when his other hand is in a wash basin or his feet in a bath tub. Cases of death by electrocution by the house current have occurred under such conditions.

There are also the dangers from the city gas that we cook with nowadays. Old and defective rubber tubes leading to gas stoves are liable to break and to allow the gas to escape. Deaths from this cause are common. Water heaters, if badly arranged, may also produce carbon monoxide. Every gas heater should be connected with a chimney to prevent this danger. Another common danger nowadays is that from carbon monoxide in automobile exhaust gas. Never start the engine of your car, no matter how cold the weather, until you have opened the garage doors.

TRANSPLANTING OUR MINDS

By Dr. A. T. POFFENBERGER
PROFESSOR OF PSYCHOLOGY, COLUMBIA UNIVERSITY

I FEEL impelled to apologize for the title of my talk to you this afternoon, after having recently seen a motion picture in which personalities were transplanted. By means of electrified belts worn by each of two persons, the personality of the one could be transferred to the other with consequences that were most amusing. It is not such transplantation of the mind that I am thinking of, nor is it the interchange of the brains of two individuals about which I have recently read in an exciting bit of fiction. It is the far less spectacular process of imagining yourself in the other fellow's place.

In the days when successful men of business and industry were wont to explain their success in the popular magazines—how long ago it seems since there were such successful business men!—there was one trait that always received a fair share of the credit. That was the knack of getting along with other people. It was attributed to the ability to project oneself into the other person's circumstances, to step into his shoes, to see problems through his eyes. Whatever expressions might be used to describe this magic operation, they all boiled down to this knack of imagining oneself in the other person's circumstances and thinking what one would do in his case. Of all the explanations suggested for the present economic disaster, I have never heard any one attribute it to the practise of transplanting minds, as I have defined it. On the contrary, every interpretation that I have studied would acknowledge the failure to transplant minds, in the sense in which I have used this expression, as an essential element of the problem.

The rapid changes in social and economic conditions which are occurring throughout the world have not affected all people in like manner or to a like degree. As a consequence, there never

was such a need as at present for great public leaders who could see problems through other people's eyes; and there never was such a need for every one to exercise the same bit of magic. Differences in outlook exist between races, between nations, between economic strata, and between social strata, between those who are employed and those who are not, between the employer and the employee, between parents and children, between the farmer and the city worker, between the white collar worker and the laborer, between the radical and conservative, between union and non-union men, between the racketeer and the law-abiding citizen. If each of these groups or individuals could project himself in imagination into the circumstances of the other, how soon the problems would be dissolved.

If the employee secure in his job could in imagination exchange his state of mind for that of the person who, through no fault of his own, is out of a job, he would get real satisfaction in relinquishing a percentage of his salary for the unemployed. If the family of the former wage-earner, now out of a job, could see the situation as he sees it, there would be more forebearance and sympathy with his depression and his irritability.

There is nothing new in what I have said, and I am sure there will be no objection to it. In fact, it is merely a kind of round-about definition of sympathy, which means feeling oneself into the situation or circumstances of another.

The problem consists in discovering how this transplanting process can be facilitated, and it is that which I wish to discuss with you. The one great underlying condition of sympathy is knowledge or information. We can not conceivably put ourselves in the place of another unless we know about him. This is true whether we are dealing with the relationship of one nation to another or one individual to another. Those persons who are most deeply concerned with international problems recognize the essential need for the mutual exchange of information. Many agencies have been set up for such exchange, although on a relatively small scale. There are exchange professorships, exchange scholarships, traveling fellowships, international student residence halls and international conferences of all sorts. The great peace conferences, economic conferences and armament conferences will accomplish much in the minds of those who are directly affected by them.

What is needed is a similar spread of information among the great masses of the population. Even here there is occasion for encouragement with world newspaper services, motion pictures and international broadcasts. The world is rapidly becoming smaller and more closely interrelated. Our public school system could and should do a great deal more than it does to further knowledge and understanding of places and peoples. It has control of the minds of the young, just at the time when sympathies as well as prejudices are most readily formed.

Every intelligent person should consider it his duty in times like these to get what authentic information he can about other nations and other peoples, by travel, by reading or whatever other means may be available. It is worth remembering in this connection that information about individuals is always more effective in arousing sympathy than information about whole populations or whole nations or whole races made up of these individuals. The detailed story of one starving Chinese is more effective in eliciting a charitable response than the mere report of a million Chinese dying from famine. The remarkable response each year to the

New York Times appeal for "The Hundred Neediest Cases" is due in large measure to the detailed account of each case, thus furnishing the means by which the reader may put himself in the place of the other. Without such a recital of conditions, the response would be cool.

The maudlin sympathy extended to the hardest criminal, so frequently deplored, is the direct result of the vivid descriptions of him presented by the press. People do not thus deliberately intend to defeat or weaken the ends of justice, but their sympathy is the immediate effect of knowledge.

Such instances as this show the involuntary character of sympathy. They should be encouraging instead of depressing, in that they demonstrate the possibility of engendering broad sympathies, of putting ourselves in the places of other persons, groups, nations and races, if their cases can be as vividly portrayed as that of the condemned criminal.

Still, I must hasten to add that the feat of mind transplantation is not so simple as I have made it to appear thus far. Something more is needed, and that something is a knowledge of how people's minds work. Now, I do not mean to suggest that every one must become a psychologist in order to acquire the essential sympathy and understanding that our present-day problems require. No profound knowledge of how the mind works is necessary, at any rate, for a few simple facts will suffice. Would it not enable us to see more clearly through the eyes of the social revolutionist whose conclusions appear so illogical, if we could discover that our own ideas are equally illogical? Or to look with sympathy upon him whose greed for money or ambition for power leads him into the toils of the law, if we were to discover that the same impulses are driving us, too, but perchance with a more fortunate outcome?

"Know thyself" is a bit of advice almost as old as written communication, but it is as important to-day as when it was first expressed. To know ourselves requires that we shall be able to examine and report our findings without prejudice or favor. That this is not easy to do was doubtless in the mind of Robert Burns when he wrote:

> Oh, wad some power the giftie gie us
> To see oursel's as ithers see us;
> It wad frae monie a blunder free us
> And foolish notion.

When we do succeed in seeing ourselves in this objective fashion, one of the first things we find is that our actions are seldom the result of the application of cold logic or reason. We seldom, if ever, think things out and then come to a conclusion. Our lives are guided far more by our emotions than by our reason. The demonstration of the importance of the emotions in everyday life is the great contribution of the Freudians to modern psychology. They have popularized the term rationalization to describe the way our minds work. It is a kind of thinking backwards, a means of giving rational support for something that we have already decided to do, or for something that we wish to believe. William James, forty years ago, pointed out this peculiarity of the human mind, and recent laboratory studies have given support to it. For example, in one experimental study of beliefs it was found that the relationship is much closer between our beliefs and the things we wish to believe than it is between those same beliefs and the quality and amount of evidence bearing upon those beliefs.

Modern advertising capitalizes this peculiar human trait. It arouses our desire for the object which it offers by appealing directly to some one or more of our many appetites, and having done

this it helps us to support our action by a kind of logic. Rigorous thinking would require that we accumulate evidence, get all the facts, and then after an examination of these facts reach a decision. It will be clear to all of us that the positions we take on many or most of the vital questions of to-day can not be the result of thinking, but must certainly be the result of this short-cut rationalizing process. It would not be possible in our busy lives to do otherwise. It seems, moreover, to be in our natures to avoid thinking, if any less arduous substitute can be found. Even a rigorous scientific training does not entirely counteract this tendency.

Let me assure my hearers that it is not my purpose to reconstruct our mental machinery by a few words of advice. We can not so readily mend our ways. It is my purpose rather to beg that we take an objective attitude toward ourselves, and look with humility upon the beliefs and attitudes which we cherish with such vehemence. Having achieved this end, we can react with sympathy and understanding toward the minds of others whose differing racial background, national history, social status or economic security give them an equally different outlook on life. To inform ourselves thus concerning other people and to see them with the understanding that can only come from a real knowledge of oneself, would in truth make this world a more fit place in which to live.

"SQUARING THE CIRCLE"

By Dr. EDWARD KASNER
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I AM going to talk about the most famous problem in the entire history of mathematics, known as "the squaring of the circle," or more technically, "the quadrature of the circle." I shall discuss also two other problems which became famous among the Greek geometers, namely, "the duplication or doubling of a cube" and "the trisection of an angle."

These three problems have occupied the attention of great and small mathematicians for the past two thousand years, and interest in them will never cease. The main reason for this interest is that all three problems, in spite of their apparent simplicity, are not merely difficult, but are actually impossible. What is meant by this impossibility? That is the main point which is usually misunderstood, and I shall proceed to clear up the misapprehensions connected with the subject.

Mussolini, in a recent interview with Emil Ludwig, made this statement, "There is no such thing as the impossible." That may be true in the domain of statesmanship or of physical inventions, but it is certainly not true in mathematics.

The squaring of a circle, in the way in which the problem is to be understood, is absolutely impossible. It has never been done and it never will be done. What is the problem? It is to construct a square equal in area to a given circle by means of an exact theoretical plan, using only two instruments, the ruler and the compass. By a ruler is meant a straight edge, that is, an instrument for drawing a straight line, not for measuring inches or lengths. By a compass we can draw a circle with any center and any radius. These instruments are to be used a finite number of times (so that we can not use limits or

converging processes with an infinite number of steps), and the construction, by purely logical reasoning, depending on Euclid's axioms and theorems, is to be absolutely exact. Of course if we give up any of the requirements stated above the problem becomes possible. Very approximate solutions with ruler and compass are known in great variety; and exact solutions with higher instruments, like rolling wheels and integraphs, are easily obtained. The impossibility arises because we demand an *exact solution* by means of *ruler and compass*, employed a *finite number of times*.

The Greeks and later mathematicians tried to find an exact construction with ruler and compass and always failed. Does that show the impossibility? Of course not. It might merely indicate the difficulty of the problem.

For centuries the problem of constructing a regular polygon of 17 sides was considered difficult and even impossible. Yet the nineteen-year-old mathematician, Gauss, in 1796, succeeded in finding an elementary construction. In the case of squaring the circle, however, all doubts were finally removed in the year 1882, when a German mathematician, Lindemann, published a proof that the problem is impossible. The proof is long and complicated, since it requires the establishment of the fact that the number π, the ratio between the circumference and diameter, is transcendental. Up to the year 1882 circle squarers had the moral right to try to solve the problem, but after that date their efforts are to be regarded as waste of time and deserve no consideration from serious scientists.

The fact that the two other famous problems of Greek geometry are also impossible was settled about one hundred years ago. The duplication of the cube involves the cube root of two, and this can not be found by ruler and compass. There is a story among the Greeks that this problem originated in a visit to the Delphic Oracle. There was an epidemic at that time and the Oracle said that the epidemic would cease only if a certain cubical altar to Apollo was doubled. The masons and architects made the mistake of doubling the side of the cube, but that made the volume eight times as great. The Oracle was not satisfied so the Greek mathematicians began to see that the right answer involved, not doubling the side, but rather multiplying the side by the cube root of 2. This they could not do geometrically with ruler and compass. Finally they succeeded by using other instruments and higher curves, and the epidemic ceased.

A few words now about the final problem, trisecting an angle. This has received a good deal of attention in the newspapers during the past few years on account of the fact that several teachers of mathematics in high schools and colleges in this country have claimed that they have solved the problem completely.

It turns out, however, that all these published solutions are absolutely incorrect. The error committed is usually of one of four kinds: sometimes the solution is merely approximate instead of exact; sometimes instruments other than the ruler and the compass are used, consciously or unconsciously; sometimes there is a logical fallacy in the pretended proof; sometimes only special arbitrary or general angles are considered. New trisectors will always appear, but newspapers should not give them any further attention.

As long ago as 1775 the Paris Academy was so overwhelmed with pretended solutions from circle squarers and angle trisectors that a resolution was passed that no more would be received. This was, perhaps, a little unwise, because at that time impossibility was suspected rather than proved.

Of course Mussolini, whom I quoted before, is correct in suggesting that we must not say too rashly that any problem which is considered very difficult in a certain stage of culture is actually impossible. Several good scientists of two generations ago are on record as saying that it would forever be impossible to invent a practical heavier-than-air flying machine. The French philosopher, Auguste Comte, said that it would always be impossible for the human mind to discover the chemical constitution of the stars. You all know how, not long after that statement was made, the spectroscope was applied to the light of the stars, and now we know perhaps more about the chemical constitution of the stars, including those in the distant nebulae, than we know about the constitution of the earth with its largely unknown interior. Helium was discovered in the sun before it was found in the earth.

Is the problem of "shooting a rocket to the moon" impossible? No, it is merely very difficult. It would be much more difficult to reach the planets or the sun or a distant star, but we have no right to apply the adjective "impossible." Such problems seem extremely hard, and perhaps will not be solved for millions of years, but we have no logical ground at the present time to say that they are absolutely impossible. However, in the case of "squaring the circle" or "trisecting the angle" (with the restriction to ruler and compass of course) we have the right to say now that they are forever impossible, because we have found logical proofs, involving purely mathematical reasoning, of their impossibility. The assumption that they can be solved leads to a contradiction. (Prof by *reductio ad absurdum.*)

Why is it that an angle can be bisected but can not be trisected by elementary geometry? Because the first problem involves merely square roots and the latter cube roots, and only square roots can be constructed exactly with ruler and compass, that is, by a finite set of straight lines and circles.

Why is it that a regular polygon of 3 sides or 5 sides or 17 sides can be constructed, but not a regular polygon of 7 sides or 11 sides or 13 sides? Exactly the same reason applies, though the algebraic reasoning is somewhat more complicated.

A square can be duplicated, namely, by drawing a square on the diagonal of the given square; but a cube can not be duplicated because the cube root of 2 is involved. (In space of four dimensions, I may remark, the figure corresponding to a cube, called a "tessaract," can be duplicated because the fourth root of 2 can be written as the square root of the square root of 2.)

Why is it, finally, the circle can not be squared, and can not be rectified, that we can not find a square of the same area, or a straight line segment of the same length? Because in both cases the Archimedean number π (which is defined as the ratio of circumference to diameter) is involved, and this number, since it can not satisfy any algebraic equation with integer coefficients, as proved by Lindemann, is surely not expressible by the rational operations or the extraction of square roots; and only these operations can be translated into an equivalent ruler and compass construction. The parabola is a more complicated curve than a circle; still the area of any parabolic segment can be found in rational form, and hence the curve can be squared.

Another subject of interest is the calculation of the number π, a number which may be called the most important number in the whole history of mathematics. It is approximately equal to 3, as stated in the Bible. A better approximation, known to the Egyptians, was 3.16. Archimedes found the approxima-

tion 3½ by considering inscribed and circumscribed regular polygons of 96 sides. The familiar decimal 3.1416, used in our school books, was known at the time of Ptolemy (150 A. D.). Theoretically we can use Archimedes' method to calculate the value of π with any degree of approximation by increasing the number of sides of the polygon, although the requisite calculations become very cumbersome. During the Middle Ages such calculations were made; but after the invention of the calculus by Newton and Leibnitz, very efficient methods were found, depending upon convergent infinite series, by which it was possible to carry out the result to many decimal places.

Here is the record of progress. In 1596 a Dutch mathematician, Ludolph van Ceulen, calculated 35 decimal places, in fact, the 35 digits were carved on his tombstone in a Leyden church. The Germans still call the number the Ludolphian number. This name is not used in other countries. I would like to suggest a name which I think would be the best, namely, I suggest calling π the *Archimedean number*. I feel sure that Archimedes deserves this honor even at this late day.

In 1699, an Englishman named Sharpe calculated 71 decimal places. In 1824 a German, Dase, a lightning calculator employed by Gauss, worked out 200 places. In 1854, Richter computed 500 places. In 1873, an Englishman named Shanks calculated 707 places. This is still the world's record, and if any American wants to become famous, let him beat this record, let him calculate 1,000 places for good measure. It would perhaps involve 10 or 20 years of calculation, but that does not seem like waste of time in comparison with the billions of hours spent by millions of people on cross-word puzzles and contract bridge. A survey of the mental energy wasted by the inhabitants of this planet would be interesting. Perhaps it would be sufficient if concentrated on the number π, for the computation of a million or a billion decimal places.

Of course, such a calculation would not be of any conceivable practical use in applied science. We never need more than perhaps 10 decimals. Professor Newcomb remarked, "Ten decimal places are sufficient to give the circumference of the earth to the fractionth of an inch, and thirty decimals would give the circumference of the whole visible universe to a quantity imperceptible with the most powerful microscope."

But still the Archimedean constant, as I like to call it, is the most famous number and the most important number ever conceived by the human race in its centuries of thinking, and therefore, this particular number should be calculated to many places. We know *a priori* that the decimal will never end, because it is known that the number is irrational and in fact transcendental.

The efforts of computers, like Shanks, are of value chiefly in showing the superiority of modern analytical methods over ancient synthetic methods. The results of these extended calculations reveal nothing concerning the real nature of π, nothing as to whether it is rational or irrational, nothing as to its transcendental character, nothing as to whether it is constructible with ruler and compass. The familiar number $\sqrt{2}$, when written as a decimal (it has perhaps never been computed to more than 200 places), would appear just as complicated, for it never ends and never repeats, and there is no known simple law giving the succession of digits: yet this complicated decimal is easily obtained exactly by a ruler and compass construction, namely, by drawing the diagonal of a square whose side is unity. When the Greek philosophers discovered that $\sqrt{2}$ is not equal to any rational number

they celebrated the discovery by sacrificing one hundred oxen. How many oxen would they have sacrificed if they had made the more profound discovery that π is a transcendental number?

If you want a simple example of a problem which is mathematically impossible take the question of finding two odd numbers whose sum is 21. It is clear that this can not be done, because the sum of any two odd numbers is always an even number.

A more difficult example of impossibility is that of satisfying the equation $x^3 + y^3 = z^3$ by any three positive integers. The impossibility was shown by Euler. The bisection of an angle or of a line segment is impossible with the ruler alone. (The bisection of a line segment is possible with the compass alone.) The solution of the general equation of fifth degree, in one unknown, is impossible by a finite combination of radicals. All these questions have been settled.

An unsettled question is the possibility of integers satisfying $x^n + y^n = z^n$. Another is the possibility of coloring all maps in a plane, or on a sphere, by means of not more than four colors.

The three most famous difficult numbers in mathematics and physics are the Archimedean constant π, the Napierian constant e, and the Eulerian constant γ. The first two of these are known to be transcendental (Lindemann, 1882, and Hermite, 1873) and are related by the marvelous equation $e^{i\pi} + 1 = 0$. The Eulerian constant is suspected to be transcendental, but this has not yet been proved. For all we know it may be that it is rational or that it is constructible with ruler and compass. We do not know. I hope that some one in my radio audience will settle this question and thus become immortal.

EXCAVATIONS AT UAXACTUN[1]

By OLIVER G. RICKETSON, Jr.
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In the New World three distinct aboriginal civilizations developed three apogees of indigenous culture. These are the Aztec in the Valley of Mexico, noted for their military organization; the Inca in the Highlands of Peru, whose despotic, if beneficent, paternalism permeated every fiber of their politico-social fabric, and the Maya of Middle America.

We may justly rank the cultural achievement of the last as intellectually the highest, in that their genius developed not only an accurate calendric system, whose numeration called for the independent invention of zero and place-numeration, but also the orderly development of a pleasing architectural style and its concomitant decoration. Their architecture never violated the principles governing proportion and mass; its decoration, even when it appears florid to Western eyes, observes the fundamentals of design, and in their handling of perspective, the Maya surpassed all the ancient civilizations of the Old World previous to the Minoan.

It is with a sample of this highest aboriginal American civilization, as exemplified in the ruins of Uaxactun, Guatemala, that we are here concerned. So great are the lacunae in our knowledge, however, that the original name of this site is forever lost to us. It was given its present name on May 5, 1916, by its discoverer, Dr. S. G. Morley, an associate of this Institution.

On entering A-Group the first object that met his eye was Stela 9, bearing the Maya calendric inscription 8. 14. 10. 13. 15. *8 Men 8 Kayab*—or June 10th, 68 A. D. Since this was the first monument bearing a cycle 8 glyph, Dr. Morley named the ruin "Uaxactun"—from the Maya *uaxac*, meaning eight, and *tun*, stone. It is the oldest dated stela so far discovered in the Maya area. The latest date found at Uaxactun corresponds to 639 A. D. So that we have here a dated span of 571 years; that is to say, a period three and one half times longer than the United States have existed as a free and independent country. Yet archeology has afforded us every proof that Uaxactun was occupied long before the erection of the earliest stela—just how long it is difficult to say, but the sixth century before Christ would be a conservative estimate. Since we have positive proof that the Maya reused stone stelae, effacing one date to set up another, this custom offers a partial explanation for the lack of earlier dated monuments; but perhaps a better explanation lies in the supposition that dates may well have been carved first on wood rather than on stone. With the climate of Yucatan such as it is we can never hope to find traces of these.

Before I describe the actual excavations themselves, permit me a moment to describe two basic factors—environment and race—an understanding of which is necessary for a clear comprehension of the situation.

Environment is a basic factor which can not be ignored. As you are all aware, the peninsula lies within the tropics; the year is characterized by two seasons, the "rainy" and the "dry." Since the whole region is composed entirely of porous coralline limestone, permanent surface water is rare, despite a heavy rainfall; in fact, the present sur-

[1] A lecture delivered at Carnegie Institution of Washington, November 3, 1931.

face-water supply is so scant that it could not have met the needs of the ancient Maya during the dry season when their population was at its peak.

Various theories have been advanced to explain this condition, of which the most convincing is that of C. Wythe Cooke after a visit to Uaxactun this year. This theory is that the present-day *bajos* or logwood swamps, covering about 40 per cent. of the terrain, were formerly shallow lakes. The rapid erosion of the surface soil, following deforestation by the Maya, has silted up these lakes. Beyond the geologic evidence supporting this theory, namely, that the mud of these swamps is composed of black carbonaceous clay and disintegrating limestone—we should remember that the district itself is called the "Peten," a word meaning "lake" in Maya—and that the silting up of these former lakes would react very unfavorably upon the environment of the ancient inhabitants in at least two ways: first, because the origin of the silt is the surface soil of the higher land, composing the terrain suitable for agriculture. Its complete denudation would mean crop-failure and the consequent collapse of a civilization based on corn; and second, because the transformation of a lake into a morass not only eliminates rapid communication and easy transport by canoe, but changes the whole aspect of the region and renders land-transport well-nigh impossible by the development of such extensive swamps that they can not be avoided and must be crossed.

The normal increase of population is sufficient to account for a slow but steady expansion in search of new land; if, in addition to this population increase, we have also the progressive onset of these

FIG. 1. PRIMITIVE TYPE FIGURINES

SHOWING FLATTENED FOREHEADS CHARACTERISTIC OF ANCIENT MAYA SKULLS. UPPER RIGHT—FROM BLACK DIRT STRATUM, UAXACTUN. AT LEFT AND LOWER RIGHT—FROM PALENQUE.

mutually interactive conditions, soil-denudation and lake-silting, we have a condition wherein expansion will be under forced draught, so to speak. This expansion, however, is no more of an exodus than was our own westward expansion across the Great Plains in the nineteenth century.

The sharp division of Maya history into two epochs—a so-called "Old Empire" in the south, abandoned in the seventh century A. D., to be followed later by a "New Empire" in the north, will have to be revised in the light of our present knowledge. The earlier centers were not abandoned; they merely yielded their prestige to new rivals. Incidentally, we should also explain that Maya ruins are not the remains of extensive cities; the Maya were not an urban people, but agriculturists. Even in the large, multi-chambered buildings of northern Yucatan there would not be housing facilities for a large population.

The ruins that we see to-day are the civil and religious centers to which the surrounding farmers flocked on market- and feast-days. Proof of this statement is evidenced by the fact that the low platforms forming ancient house-mounds extend throughout the jungle in every direction and without demarcation between one center and another.

By taking a sample count of these mounds and allowing the jurisdiction of such a center as Uaxactun to extend ten miles in every direction, we arrive at the conclusion that the population could not have been less than 48,000, providing that only 25 per cent. of the house-mounds were simultaneously occupied. If all the arable land were equally divided among all the house-mounds, each householder would own a lot 125 yards square. With intensive agriculture, such a lot would produce sufficient, and more than sufficient, corn, beans and squash for one family.

Our second basic factor is race. We definitely know that at Uaxactun we are dealing with a Maya race pure and simple. No evidence is at hand that any other type ever occupied this site. Such skeletons as have been encountered indicate that the individuals were markedly brachycephalic, of relatively light skeletal set-up and of equal stature with living Maya stocks as found in northern Yucatan and the Highlands of Guatemala to-day.

Two wide-spread characteristics of ancient Maya skulls are also seen at Uaxactun—fronto-occipital deformation, in which the forehead is purposely flattened (see Fig. 1), and the filing of the incisor teeth. We therefore assume, in the light of our present knowledge, that the first and original settlers of Uaxactun were of Maya stock, no evidence of a preceding race of inhabitants ever having been discovered. Not only is there no archeological evidence, but in the Book of Chilam Balam of Chumayel, which recounts legendary lore of the Maya, there is this statement in regard to the arrival of the Mayas. "They named the district, they named the wells, they named the region, they named the land, because no one had arrived here, here in Ucalpeten, when we arrived here." If this is the case, then, the living Maya can claim 2,500 years of continuous residence in the Peninsula of Yucatan, during which time the majority of their race has maintained its physical characteristics even up to the present day, and this in spite of the shock of the Spanish Conquest.

With these two factors in mind, let us now turn specifically to the ruins of Uaxactun themselves. These lie in the north central portion of the Department of the Peten, Guatemala (see map, Fig. 2) at the geographic center of the Yucatan Peninsula, in a dense high jungle which is to-day completely devoid of all permanent human habitation between

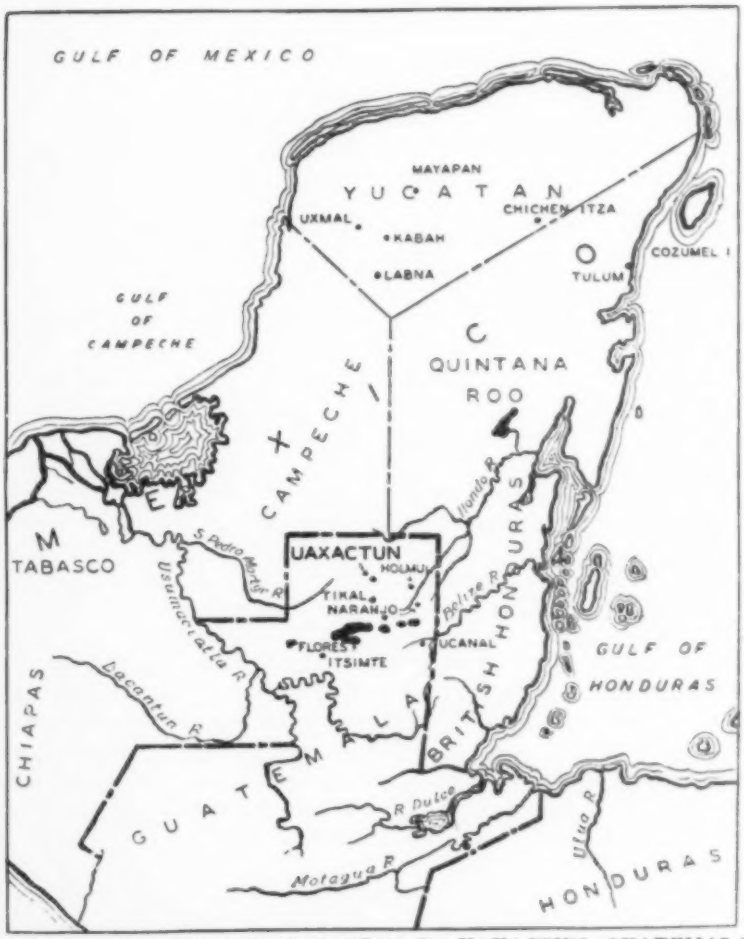


FIG. 2. SHOWING THE LOCATION OF UAXACTUN, GUATEMALA

SITUATED AT THE GEOGRAPHIC CENTER OF THE YUCATAN PENINSULA, IN A DENSE, UNINHABITED JUNGLE.

Peto, Yucatan, on the north and Flores, Guatemala, on the south.

So difficult are the conditions of travel that we may safely say the only people who penetrate the region are archeologists in search of ruins and chicle-bleeders in search of the indispensable ingredient of chewing-gum—the gum derived from the latex of the sapote tree. Although Uaxactun lies only 120 miles in an air line from Belize, British Honduras, yet the journey generally consumes a week or more—three or four days to ascend the Belize River in a 60-foot launch, and five days riding a mule as it alternately flounders through logwood swamps or crawls along the tortuous trails at the bottom of the jungle.

Twelve or fifteen miles is considered a day's journey during the "dry" season—less when the rains render the trails barely passable. The day's journey is also controlled by the location of *aguadas* or water-holes, for this is a country where running streams and springs are unknown, and camp must

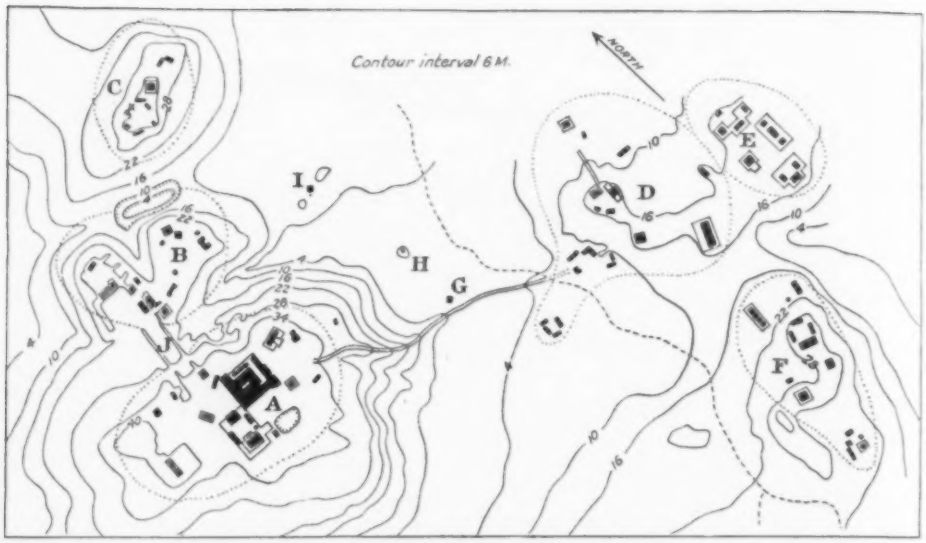


FIG. 3. MAP OF UAXACTUN (AFTER BLOM)
SHOWING: A, B, C, D, E, F, IMPORTANT GROUPS OF STRUCTURES; G, LABORERS' CAMP; H, AGUADA; I, STAFF HEADQUARTERS.

be made at water, of course. Perhaps the strongest impression the jungle makes on the outsider entering it for the first time is a sensation akin to suffocation—not from the heat, because the sun never penetrates the bottom, but from the subdued, green light and the still, silent air, unruffled by the slightest breeze.

Contrary to popular opinion, the monotony of the jungle trail is seldom broken by animal life, if we except the wail of the howler monkey. Although there are two of the large cats, the jaguar and the puma, and several of the small, such as the ocelot, these are nocturnal, as is also the largest denizen, the tapir. Two kinds of deer occur, and various small mammals, such as the armadillo, the agouti, the coatimundi and the more rare kinkajou.

On the other hand, bird-life is teeming, and contains one unique species not seen elsewhere—the beautiful ocelated turkey of Yucatan. Snakes, though well represented, find much of the country too wet; the best-known species of poisonous snake include the fer-de-lance, the tropical rattler and the coral-snake, but, again, contrary to popular opinion, these do not offer any particular hazard, and snake-bite would result only from treading directly on one. In fact, life in the jungle is a great deal safer than in one of our modern cities—the only enemies being malarial fever and intestinal infections, neither of which are even remotely liable to prove fatal with our present-day medical equipment. I may add, however, that if the safety-factor compares well with that of our modern metropoli, the comforts certainly do not. There is no more comparison between a Pullman and a pack-train than there is between a modern hotel and a bush *champa* (lean-to).

But we are digressing from our main subject; the map of Uaxactun (see map, Fig. 3) will show us that these ruins occupy the artificially flattened tops of natural hills, as is so characteristic of Maya sites in the Peten. More or less

centrally located may be seen the Main Aguada, north of it the Institution's field headquarters and south of it the laborers' camp. On the west, crowning the highest eminence, is Group A—here we have a standing building A–XVIII not of a temple but of a domiciliary type facing the East Plaza; the South Plaza bounded on the north by an entirely fallen but extremely massive and complex structure, A–V, containing 3 sunken courts; on the east by the South Terrace; on the west by the South Court, and on the south by the natural slope of the hill.

The South Court, already mentioned, is in itself a complete temple-plaza unit. Its chief temple, A–I, surrounded by 9 stelae, is the site of an important pottery cache which I will describe later on. North of it lies the Main Plaza, in which stands Stela 9—bearing the earliest date, 68 A. D.—from which extends an artificial causeway along a natural ridge to Group B.

This group, as can be seen, occupies the double top of a forked hill—the western plaza is called the Main Plaza, the other the eastern. B-Group stands 10 meters lower than A-Group. It is composed of large low mounds, of secondary importance to A-Group.

The third group, C, is an irregularly oriented collection of 9 mounds, crowning the top of a hill northeast of B-Group, and separated from the East Plaza of the latter by a steep-sided ravine. It contains no stela.

These three groups comprise the portions of Uaxactun west of the aguada. East of it are the two widely scattered groups D and F and the compactly built temple-plaza unit called Group E, or the Group of the Solar Observatory. This latter is the site of the excavations carried out by the institution during the past six years, and was chosen for two reasons. (1) The three stelae in its plaza, though not the earliest, still bear very early dates—98 A. D. and 235 A. D. (2) Frans Blom, who visited Uaxactun for the Carnegie Institution in 1924, noted that certain lines of sight from Pyramid VII to Pyramids I, II and III, respectively, corresponded very closely to the amplitudes of the sun at the solstices and the equinoxes. Excavations have proved that the positions of these temples are closely related with these four cardinal markers of the year,

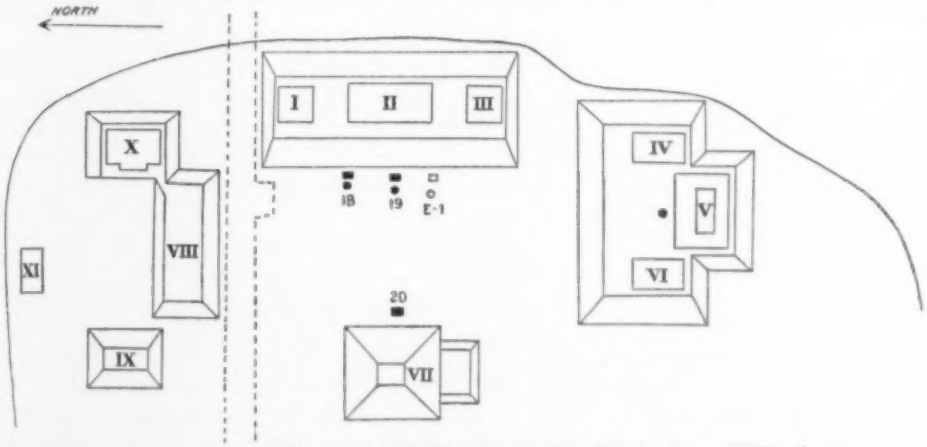


FIG. 4. GROUND PLAN OF GROUP E

SHOWING LOCATION OF THE MAIN TRENCH. THIS GROUP COMPRISES ELEVEN MOUNDS, GROUPED AROUND ONE MAIN PLAZA.

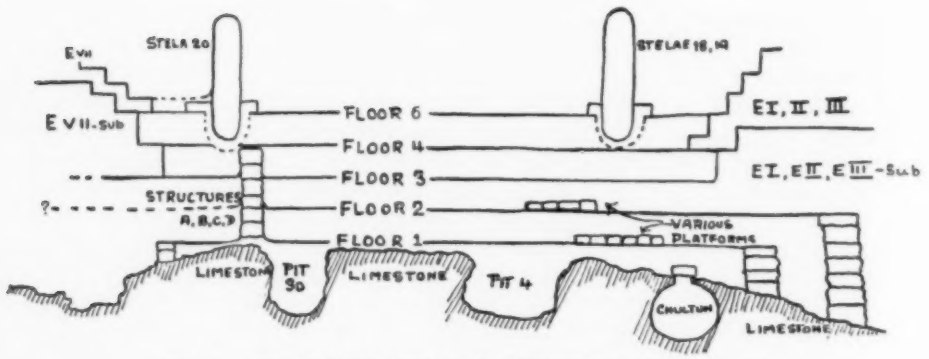


FIG. 5. DIAGRAMMATIC CROSS-SECTION OF E-PLAZA

SHOWING SUPERPOSITION OF PLAZA FLOORS. FLOOR 5 HAS BEEN OMITTED. STELA 20, DATED 235 A. D.; STELAE 18, 19, DATED 98 A. D.

probably for purposes of geomancy rather than for actual observation in a modern astronomic sense.

The group was also chosen for excavation because of its compactness, which would permit its thorough examination in a period of five years.

An examination of the map (Fig. 4) shows that this group comprises eleven mounds, grouped around one Main Plaza and a smaller North Court. All but one are in complete ruin.

Temples I, II and III surmount a 15-foot mound, closing the main plaza on the East; Temples IV, V and VI surmount a similar mound, closing the main plaza on the south; Pyramid VII stands solitary on the west. It was from a position on the stairway leading up to this structure that the lines-of-site to I, II and III marked the cardinal points of the year. On the north the plaza is closed by a long, enigmatic mound, VIII, whose adjacent structures, IX on the west and X on the east, enclose, with the aid of Pyramid XI on the north, the North Court. Temple X is partially standing, a condition found elsewhere in Uaxactun only at A–XVIII.

Temples I, II and III were those first excavated. These were found to consist of an outer and inner room, the latter invariably containing a low masonry altar. In the floors of all these temples were small circular cists with caches of two types; one type consisting of two flat-bottomed redware dishes with flaring rims, laid the one inverted over the other, containing in the space between them a human skull. Inasmuch as the first few cervical vertebrae were found beneath each skull, it is evident that the head must have been severed from the body—and that we therefore are not dealing with a secondary skull burial, but with human sacrifice.

The second type of cache consisted of a small cylindric jar, generally lidded and barrel-shaped, which often contained a red powder—hematite—or a stone object. The most striking object found in this type of cache was a small archaic green mudstone human figurine, represented as squatting. This figurine has been called crude because early and therefore primitive, and it has been called crude because late and therefore degenerate. There is no doubt in my mind that it is primitive, but its manufacture long anteceded the erection of the temple in which it was found.

Opposite the three temples just described stood Temple VII. This steep-sided pyramid originally stood 50 feet high, but the dilapidated character of its masonry precluded the determination of

any architectural features other than that a stone-balustraded stairway once ascended its east face; just how far we do not know, for unlike the usual Maya pyramid, this was not a substructure mound with a flat top whereon a temple was erected. It continued up to a more or less sharp peak (Fig. 7).

As excavations proceeded around the base of this pyramid in a vain effort to find definite remains of wall stones *in situ*, a hard, perfectly preserved stucco surface was found directly beneath it, which upon further investigation revealed itself as an earlier pyramid completely covered over and preserved by the later one. This pyramid was called E–VII–sub and was eventually found to consist of a low terraced platform ascended on all four sides by stairways (Fig. 8). On its top sat another platform, access to whose top was had by only one stairway on the front or east.

All these stairways—five in number—were flanked by grotesque stucco masks built up over stone cores—the four

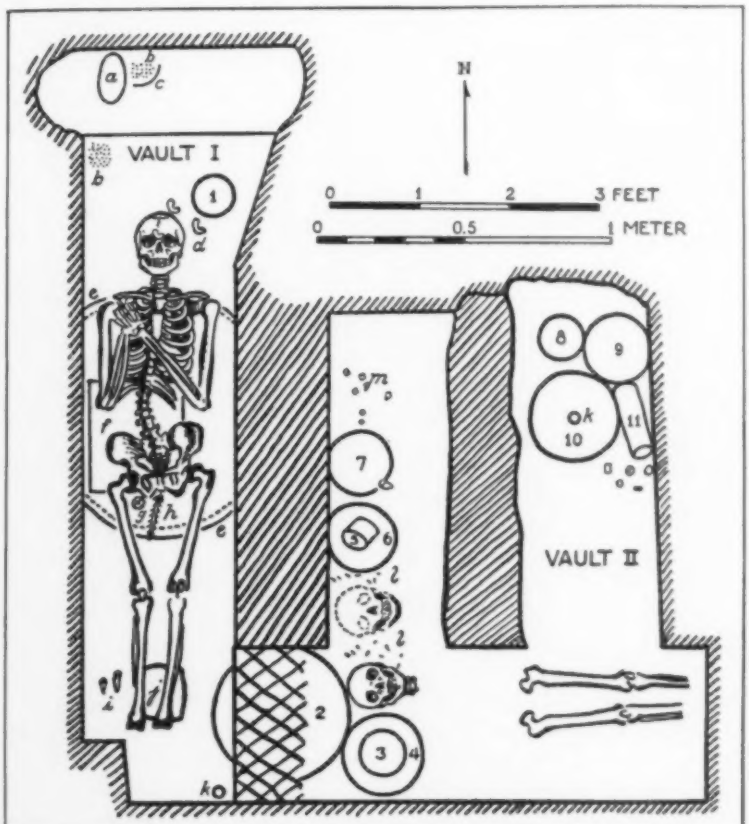


FIG. 6. DIAGRAM SHOWING THE BURIAL VAULTS AND THE LOCATION OF THEIR CONTENTS.

A, Fragmentary skull of large mammal. B, B, Carved pieces of bone pierced for use in a necklace. C, Fragment of pottery vessel. D, Sea shells. E, E, Area of charred wood underlying skeleton. F, Hole below charred wood area. G, Large jade bead. H, Tail of sting-ray. I, Deer antler. J, Large rectangular bone (turtle?). K, K, Jade beads. L, L, Human teeth. M, Iron oxide. 1–11, Pottery vessels.

main stairways of the supporting platform having two such masks on either side, the single stairway of the upmost platform having but one. There are therefore 18 masks in all, the general design of which does not conform to what we may call Classical Maya, but is yet so Maya in feeling that we have referred to it as Primitive Maya. These masks, roughly eight feet square, all represent grotesque human faces with open slit-like mouths in which exaggerated teeth are shown. Their general expression is one of ferocity. They have all a rolled ornament over the nose, and a broad band across the face at the level of the nostrils, reminiscent of a nose plug. Perhaps they carry a suggestion of the rain-god Tlaloc. Masks of similar motif, but broken down into greater conventionality, have been reported by Merwin from Holmul, a near-by ruin with which certain periods of Uaxactun pottery are to be associated, as we shall see.

Important as this discovery of an extremely early type of Maya architecture may be, the scientific importance of less spectacular excavations is even greater. This resulted from the sinking of an elaborated network of trenches into the very plaza itself. The photographs of these trenches will give some idea of their size—the first one, that of the main north-south trench—shows us how this trench appeared at the conclusion of the 1929 season (Fig. 9). It has been dug down through six superimposed plaza floors, the one overlying the other.

The six plaza floors extending across the plaza were found to overlay a deposit, varying in depth, of a black earth (Fig. 5). Beneath this was the basic limestone, so that we are more than reasonably certain that in this case we have reached bedrock.

The inferences from these trenching operations may be summarized as follows:

(1) Pits and bottle-shaped chambers called *chultuns* were found artificially excavated by the Mayas in the solid limestone at depths of 15 feet below the present plaza surface.

(2) All soil from limestone up to the present surface bore traces of man's presence in one form or another—such as burials, worked shell or flint or obsidian, and broken fragments of pottery.

(3) The lowest layer, the so-called Black Dirt, underlying the main plaza floors, is a refuse bed—a typical midden type of deposit formed by the gradual accumulation of vegetable débris, such as thatching for roofs and the débris from long occupancy by man.

(4) The lowest plaza floor is to be associated with a plaza much smaller, as compared with the latest plaza; on it are rectangular platforms presumably the foundations for the earliest structures. Whether these were of wood or of stone, they had been razed to make way for the later plaza expansions.

(5) The six plaza pavings occur directly superimposed the one upon another. From the lack of débris accumulation between these superimposed floors we assume that the period involved in their construction need not have been long. As compared with the Black Dirt accumulation, the period may well have been relatively short.

(6) The period of construction of E–VII–sub corresponds with the laying of the second and third floors of the plaza.

(7) The period of construction of E–VII outer corresponds with the laying of the fourth, fifth and sixth floors.

(8) The erection of Stelae 18 and 19, both dated 98 A. D., and that of Stela 20, dated 235 A. D., loses much positive significance, in that their floor-relations indicate these monuments to have been

erected simultaneously. In other words, the earlier ones must have been removed from their original locations. In the case of Stela 20, dated 235 A. D., we can say with some assurance that it probably marks the latest possible date for the construction of E–VII outer.

The true significance of these excavations, however, lies in the definite development of the first pottery stratification for this area, as worked out by Mrs. Ricketson. And here we are back again on firmer ground. There are three main types:

I. Uaxactun I—an early or "archaic" type. This type is found only in the Black Dirt stratum and is characterized by the following types:

(a) large ollas of unslipped orange-red ware, design in brown wash, thinly applied.

(b) small ollas of polished black ware with incised cross-hatchings generally in diamond and half-diamond designs.

(c) Round bottomed bowls, some spouted, with horizontal fluting around the neck.

(d) Flat-bottomed dishes, having everted rims with horizontal, parallel incisal lines.

(e) figurines—of definitely "archaic" characteristics, which are always modeled, never moulded or cast.

II. Uaxactun II. Middle Period. This corresponds to Holmul III. It is characterized by wide-mouthed dishes, with a basal bevel or flange, in polished black ware or with complicated polychrome designs on the exterior.

III. Uaxactun III. A late period. Corresponds to Holmul V. It is characterized by:

(1) tripod dishes, with rattle legs;

(2) shallow plates (some with tripod

FIG. 7. TEMPLE E–VII, UAXACTUN

AT CLOSE OF THE 1927 SEASON. THE TWO MASKS VISIBLE BELONG TO AN UNDERLYING PYRAMID, E–VII–SUB. STELA NO. 20, DATED 235 A. D., IS SEEN AT FRONT.

support) with polychrome design on interior;

(3) cylindrical vases with polychrome design on exterior, consisting of glyph-band and life figures.

This pottery sequence at Uaxactun seems to indicate an early influence from the south, Salvador and Nicaragua, a local development, and a later influence coming from the north or highlands of Guatemala. The nearest relationships for the Uaxactun I figurines are seen in those from the Ulua Valley, though there is also a resemblance, not so close, with the figurines from the Finca Arevalo, Guatemala.

When I mentioned Temple A–I, I said that it was the site of an important pottery cache found by Mr. Robert Smith in 1931. The cache consisted of eleven magnificent polychrome pots from a grave vault (Fig. 6). These are all of Uaxactun III period, that is, polychrome designs often with glyph-bands and life figures. I shall here describe seven of the more important of these vessels.

The first of these vessels is a simple bowl, six inches in diameter, and 3.6 inches deep, of polished orange-red ware with a conventionalized design in red and brown in four bands horizontally around the rim and sides; the second, a similar polychrome bowl, 6 inches in diameter and 6 inches deep, with the addition of black to the colors already mentioned. The third is a polychrome

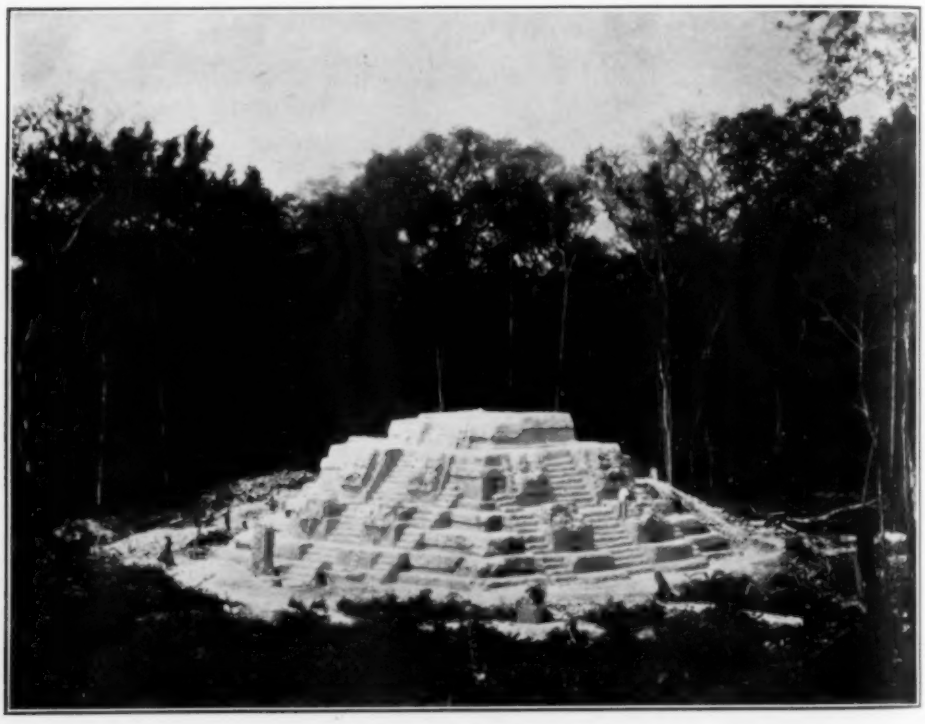


FIG. 8. E–VII–SUB.

THIS PYRAMID WAS BUILT OF UNCUT STONE AND FACED WITH DAZZLING, WHITE STUCCO. FOUR MAIN STAIRWAYS LEAD TO THE TOP. FLANKING THESE ARE COLOSSAL MASKS OF FINE, LIME STUCCO, FASHIONED IN THE LIKENESS OF GROTESQUE HUMAN HEADS. STELA E–20, AT LEFT, BEARS THE DATE OF 235 A. D.

FIG. 9. TRENCHES IN E-PLAZA

AT THE CLOSE OF THE 1929 FIELD SEASON. LATER THESE WERE DUG DOWN THROUGH SIX SUPERIMPOSED PLAZA FLOORS.

bowl, 7.5 inches in diameter and 2.7 inches deep, but with only black and red on the orange background, and with two vertical areas of red instead of the horizontal bands seen on the others.

A fourth vessel from this cache is a shallow bowl with an orange slip on the inside, unslipped and unpainted on the outside, measuring 12.25 inches in diameter and about 3 inches deep. The painted design on the interior consists of a narrow black and a broader red band around the rim, and a central figure in red outlined with black which is not identifiable, though it has some resemblance to the head and forelegs of a turtle emerging from an area of red curlicues.

A fifth vessel is a shallow, flanged tripod dish, 18.2 inches in diameter, unslipped and unpainted exteriorly but bearing on the interior an elaborate design in red and black on a buff background (Fig. 10). The flattened, slightly everted rim (2″ wide) is painted solid red for half the circumference; the other half has black spots, simulating the spots of a jaguar, on buff. Within the rim, the concavity of the plate pitches more steeply for a distance of two inches. It is set off from the rim proper by a heavy black line. This surface is painted solid red for half the circumference; the other half shows five series of hieroglyphs outlined in black but painted red.

Within these two rim areas are two concentric heavy black lines which enclose the main artistic effort . . . a boldly, if carelessly, executed picture, also in black and red, depicting full face on the right a man in regalia with a javelin or staff, looking left. The body of a serpent divides the remaining surface into an upper and a lower portion. In the upper portion, facing left, are four human figures in profile. The first on the right carries a stick; the second holds the tail of a jaguar whose body fills the lower left quadrant of the dish, below the serpent's body. Both of these human figures are standing. The third

FIG. 10. A SHALLOW, FLANGED TRIPOD DISH FROM VAULT II

ITS EXTERIOR IS UNPAINTED; ITS INTERIOR BEARS AN ELABORATE DESIGN IN RED AND BLACK ON A BUFF BACKGROUND.

and fourth figures, however, are kneeling and hold before them in their hands a monkey each.

FIG. 11. A SHALLOW BOWL

14 INCHES IN DIAMETER, ALSO FROM VAULT II. THE FIGURE IS THAT OF A MAN POISED AS THOUGH ENGAGED IN A POSTURING DANCE. THE HOLE THROUGH THE MIDDLE INDICATES THAT IT WAS CEREMONIALLY "KILLED," POSSIBLY TO RELEASE THE SPIRIT OF THE VESSEL TO ACCOMPANY THE SPIRIT OF THE DEPARTED OWNER.

The lower portion of the dish depicts the body of the jaguar already mentioned on the left; another jaguar approaches from behind the large human figure in regalia, which we first mentioned as filling the whole right-hand area. Both jaguars give the impression that they are stalking or even springing at a central human figure, apparently unclad, which is shown in profile and head down between them, in what, for lack of a better word, we may describe as an acrobatic position . . . arm on the ground, head bent back so that the face looks to the left, the body rising in a column above, and the legs flexed at the knee so that the feet hang down.

As already said, the whole has been done with boldness; in spite of its obvious complication, it leaves small areas around the periphery blank; the scene depicted is certainly ceremonial, the full face figure on the right being the master of ceremonies, the "acrobatic figure" perhaps being a corpse thrown to the jaguars. If this figure represented a form of the Diving God, one would expect it to wear insignia. Tricklets of tears from its closed eye would seem to indicate that the individual was either dead or not enjoying the prospect.

A sixth dish, 14 inches in diameter, with tripod legs, also unslipped and unpainted on the exterior, shows a central human figure in red and black on an orange-buff background (Fig. 11). The rim area is demarcated by outer and inner concentric red and black borders, 1½ inches apart, containing between them a series of non-calendric hieroglyphs painted free hand in black.

The human figure represents a man standing erect, full face, toes apart, with a large non-feather headdress and a highly deformed skull. His left arm and shoulder are raised, the palm extending outward, the long fingers pointing down. His right arm, rigid, is held

down slightly away from the body, the hand and fingers bent inwards and upwards. Feet, legs, torso and arms are red; the face, except for the region around the eyes and mouth, which are orange-red, is left the buff color of the background, as are the thighs. These latter give the appearance of being clad in puffy doublets supported by black and red sashes whose half dozen ends swirl out around the legs. Nothing can describe the position of this figure better than to say that it probably depicts some posturing dance at a moment when the arm-action is semaphoric in its rigidity. That this piece was ceremonially "killed" is indicated by the hole in the center.

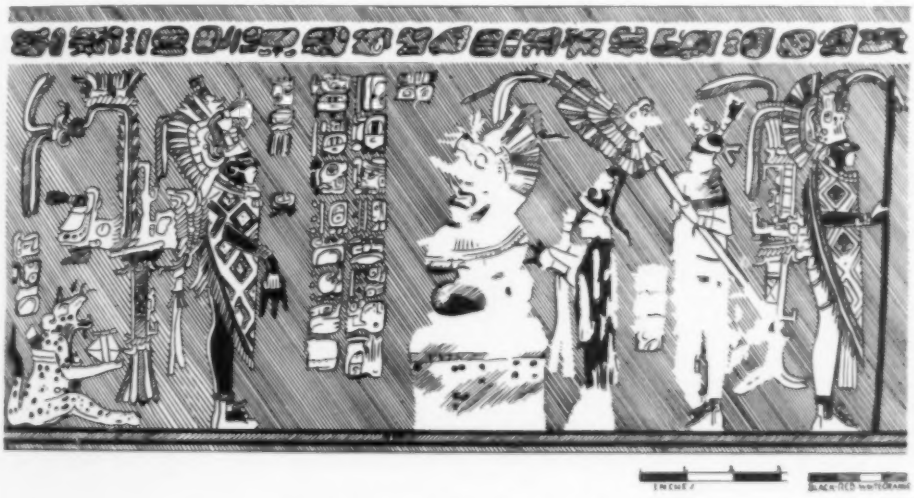


FIG. 12. A CYLINDRICAL JAR

9 INCHES HIGH AND NEARLY 6 INCHES IN DIAMETER, FOUND IN VAULT I. THIS PICTURE REPRESENTS IT AS CUT FROM TOP TO BOTTOM AND FLATTENED OUT. THE JAR IS DECORATED WITH A COMPLICATED DESIGN SHOWING AGAINST A RED BACKGROUND. NOTE THE DOUBLE ROW OF DATE GLYPHS AT LEFT OF THE SEATED FIGURE. THIS IS THE FIRST SERIES OF SUCH GLYPHS EVER FOUND ON ANY MEDIUM OTHER THAN STONE OR STUCCO. ACCORDING TO ONE SYSTEM, 120 B. C. IS THE DATE REPRESENTED; ACCORDING TO ANOTHER, 140 A. D. IS INDICATED.

The most interesting vase from this cache, and the last, is a cylindric jar measuring 9 inches in height and nearly 6 inches in diameter (Fig. 12). It is slipped inside and out with a cream-white slip, and painted outside, the design showing against a red background. Around the rim, beneath a band of red .3 inches wide, is a cream-colored band .9 inches wide bearing hieroglyphic figures outlined in black and painted for the most part red, with some pale orange. Below this band there are represented six figures, five human and one jaguar. The chief figure is represented seated cross-legged on a dais, full face, but with the head facing left. Behind it stands a smaller figure, dressed in black, bearing before him as an offering some object in his hands. Behind this figure stands a third, larger one, bearing a ceremonial staff, which he holds over the heads of the other two; the staff carries a panache of feather work at the extremity and was intended perhaps for shade as well as for regalia of office. These three figures all face left; they are unfortunately in a poor state of preservation,

the slip having peeled off, perhaps because this side was nearest the burial itself.

Facing them stand the other two figures, and the jaguar, sitting; but between the foremost of these figures and the chief seated figure we have already described is a double row of calendric hieroglyphs, eight in a column, or sixteen altogether. The first of the figures facing the seated figure is a man standing, with an elaborate feather headdress and a fringed apron-like garment extending from his neck to below his knees. His right forearm extends through this apron and he holds in his hand a small, tridentate object, the points down, resembling an eccentric flint. His skin is represented as painted black on the arm, legs and face, except for an area around the mouth, which is left cream. Behind him, as though attached at a point just below the shoulders, is a cruciform design representing a feathered serpent, whose head and jaws face left. Beneath and behind him the sitting jaguar is represented holding in his outstretched right paw two flaring rimmed dishes, the one inverted over the other, and tied together with a band.

The last figure is similar to the one last described, the essential difference being that he holds upright a plain staff in his right hand. His headdress involves a jaguar head as well as featherwork, and a less elaborate, conventionalized feathered serpent is shown behind him also, as though attached to the small of the back. All these figures stand on a narrow cream-colored band just above the bottom of the vase. Four series of non-calendric hieroglyphs are shown in juxtaposition to the various figures.

The calendric hieroglyphs, reading from left to right and from top to bottom, give us the date 7. 5. 0. 0. 0. 8 Ahau 13 Kankin. Unfortunately, this seventh cycle date can not be contemporaneous, because the vase belongs stylistically to the latest period at Uaxactun. We might infer then that the date referred back to some past event in history wherein two ambassadors appeared before a king or noble. But unfortunately the fifth katun of the seventh cycle does not fall on 8 Ahau 13 Kankin, so that it is quite evident that the potter himself made a mistake when he put on this Initial Series.

Maya hieroglyphs and their systems of bar and dot numeration being what they are, several solutions have been offered in an effort to determine the date that was actually meant. Dr. S. G. Morley adds one dot to the cycle, making it read 8. 5. 0. 0. 0; this falls on 12 Ahau 13 Kankin, so that the only other correction necessary is to change the one bar and three dots of the day-sign Ahau to two bars and two dots. This system has the merit of merely changing the numerations and not the glyphs, but on the whole it is very difficult for us, almost two thousand years later, to decide just exactly what date was meant, and, in this case anyway, the importance is not so great, inasmuch as the contemporaneity of the manufacture of the pot and the date 7. 5. 0. 0. 0 is out of the question.

The description of this cache concludes my remarks on the excavations carried out during the past six years at Uaxactun. I hope that the future excavations, which will be under the direct charge of Mr. Ledyard Smith, will uncover other caches of equal beauty and importance; perhaps it is one of the fascinations of archeology that nobody can predict what the removal of the next spadeful may reveal.

THE PROGRESS OF SCIENCE

THE CENTURY OF PROGRESS MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

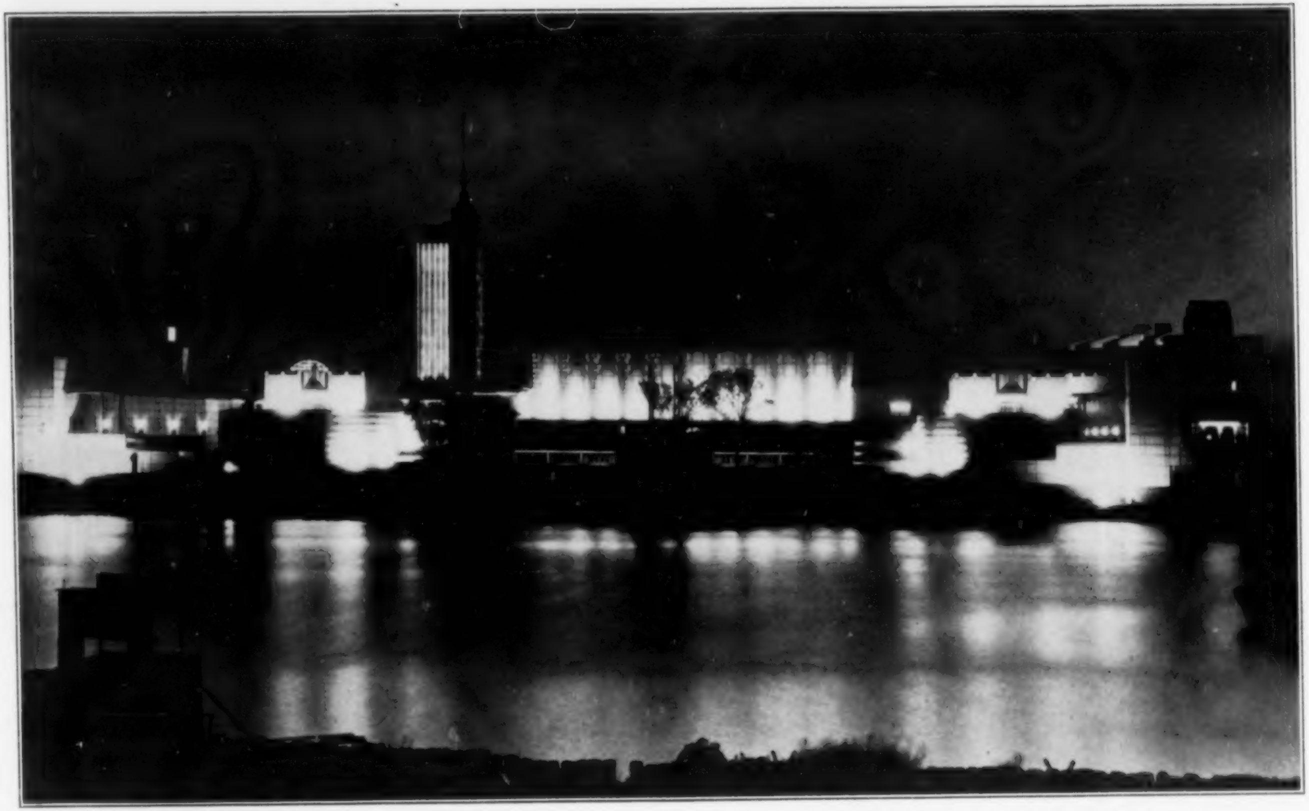
CHICAGO this summer is the Mecca of tourists from all over the world. Its Century of Progress Exposition, wonderfully planned and widely heralded, has aroused interest in every corner of the globe. Motor cars, trains, ocean liners, are bringing visitors to a huge metropolis that a hundred years ago was bare prairie.

The meetings of the American Association for the Advancement of Science at Chicago probably will be the greatest in the history of the association. The setting is perfect. This world's fair, more than any other, is dedicated to the effects of scientific discovery on the life of mankind. It is a fair that should awaken in the mind of the layman the necessity of scientific achievement far more emphatically than has any previous effort. In addition to the exposition, two large universities are cooperating toward the success of the meetings.

The exposition and the association are bringing as guests a long list of distinguished foreign scientists to contribute their views and researches at the meetings. An unusually large number of sessions will be devoted to invited papers by these and by scientists from North America. Every field of scientific work is covered, and the length of the program is such that the meetings will extend over twice the usual period. They will begin on the nineteenth and continue to the end of the month.

THE UNIVERSITY OF CHICAGO FROM THE AIR

THE UNIVERSITY BUILDINGS AND GROUNDS HAVE BEEN OUTLINED BY PARTIALLY PAINTING OUT THE AREA SURROUNDING THEM. THE GROUP OF BUILDINGS AT THE LOWER LEFT-HAND CORNER IS DEVOTED TO THE MEDICAL SCIENCES. THE INTERNATIONAL HOUSE APPEARS AT THE EXTREME RIGHT, AND THE ISOLATED BUILDINGS ACROSS THE MIDWAY COMPRISE THE NEW DORMITORIES FOR MEN.



THE HALL OF SCIENCE AT A CENTURY OF PROGRESS, CHICAGO'S 1933 WORLD'S FAIR

WHERE THE MARVELS OF SCIENTIFIC PROGRESS IN THE LAST CENTURY WILL BE UNFOLDED. THE ABOVE PHOTOGRAPH SHOWS THE EAST VIEW OF THE BUILDING, AS SEEN AT NIGHT. THE TOWER IN THE CENTER OF THE PICTURE IS ILLUMINATED WITH NEON TUBES IN A MYSTERIOUS BLUE AND ROSE COLOR. IT CONTAINS IN ITS TOP A SET OF CARILLON CHIMES. TO THE RIGHT OF THE TOWER EXTENDS A WALL WHICH FORMS THE WEST EXTREMITY OF THE GREAT COURT. THE WING SHOWN AT THE EXTREME RIGHT HOUSES THE EARTH SCIENCES EXHIBITS.

THE FIELD MUSEUM OF NATURAL HISTORY IN CHICAGO

At this meeting, with the greatest number of affiliated societies gathered together in the history of the association, it is extremely difficult to pick out sessions that stand ahead of others in interest.

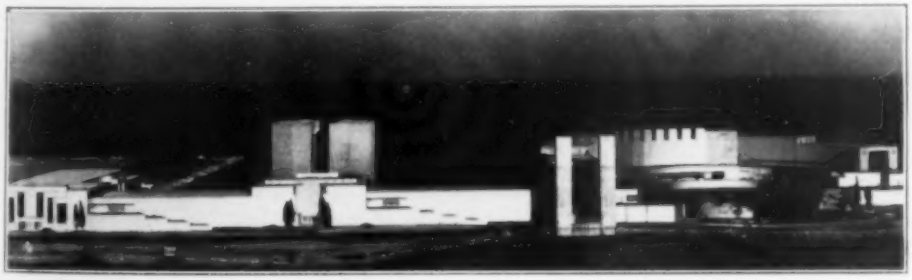
Perhaps the symposia of Section N—Medical Sciences—may be of most appeal to the general public. In one of these the progress of the past century will be reviewed by Dr. Morris Fishbein, speaking on "Frontiers of Medicine." Other participants will be Dr. Paul Dudley White on "Heart Disease" and Dr. Max Cutler on "The Conquest of Cancer."

Dr. Goldschmidt of Berlin, prominent authority on heredity and sex, is taking part in a symposium on "Heredity," whereas Professors Hill of London, Krogh of Copenhagen and Barcroft of Cambridge are giving talks on physiological subjects.

The many meetings of Section M and the affiliated engineering societies have caused the second week to be designated as "Engineering Week" and have induced the exposition to set June 28 as "Engineering Day." Attracting perhaps outstanding public attention among engineering papers will be those by Dr. A. P. M. Fleming of England on "The Industrial Development of the Century" and Dr. H. J. Gough on "Crystalline Structure in Relation to Failure of Metals, Especially by Fatigue."

Section L—Historical and Philological Sciences—holds on June 26 a symposium on "Nationalism," with guests and members speaking. "Imperialism, National and International Peace" will be discussed by Director Albrecht Mendelssohn Bartholdy, of the Institute for Foreign Affairs at Hamburg, Germany.

In the realm of pure, physical science the general session on the evening of June 21 may prove to be of greatest interest. Professor N. Bohr will preside. Dr. F. W. Aston of Cambridge, En-



ANOTHER VIEW OF THE HALL OF SCIENCE

THE SOCIAL SCIENCES ARE HOUSED IN THE LEFT WING. THE COURT ACCOMMODATES 80,000 PERSONS.

WALL WHICH FORMS THE WEST EXTREMITY OF THE GREAT COURT. THE WING SHOWN AT THE EXTREME RIGHT HOUSES THE EARTH SCIENCES EXHIBITS.

gland, will tell the "Story of Isotopes" and Dr. R. A. Millikan will speak on "New Light on Nuclear Physics." Other symposia on physical science with famous foreign and American speakers will in interest follow closely after this session.

On the same date will occur a joint meeting of Sections E, B, C and D with the American Physical Society to discuss "Measurement of Geologic Time." On the next day Sections B and D will meet with the American Physical Society and the American Astronomical Society in a symposium on "Spectroscopy and Astrophysics."

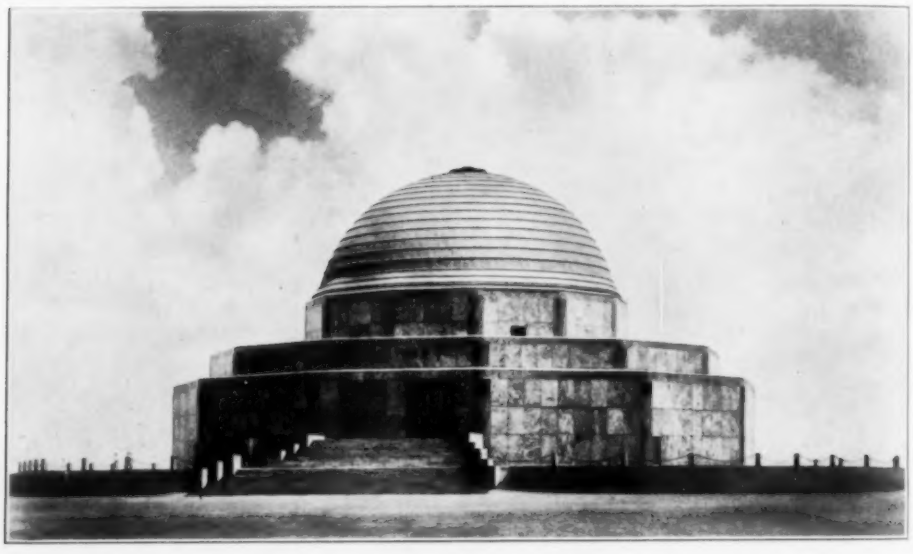
This brief summary of the meetings would be incomplete if the meetings of Section I—Psychology—were not considered. The names of the foreign guests alone are sufficient to indicate the interest. These include Professor Wolfgang Köhler of Germany, Professor Charles E. Spearman of England, Professor Henri Piéron of France and Professor Emilio Mira of Spain.

On June 23 there will be a general session on anthropology, held at the Field Museum. Director C. U. A. Kappers, of the Central Institute for Brain Research at Amsterdam, Holland, will speak on "The Anthropology of the Near East." Following this session the museum will hold an open house for the members of the association and their guests.

Dozens of other sessions would be well worth lengthy description. The fact that there are more than 300 pages in the official program testifies vividly to the inclusiveness of the meetings. It would be impossible for one interested in even the most narrow specialty not to find discussed subjects that are closely related to his special field.

On June 19 the Century of Progress Exposition is tendering a huge reception to the American Association for the Advancement of Science. This reception is in honor of the foreign guests. On other evenings during the meeting there are numerous lectures, banquets, symposia, etc. Special provision is being made for the entertainment of wives of attending scientists.

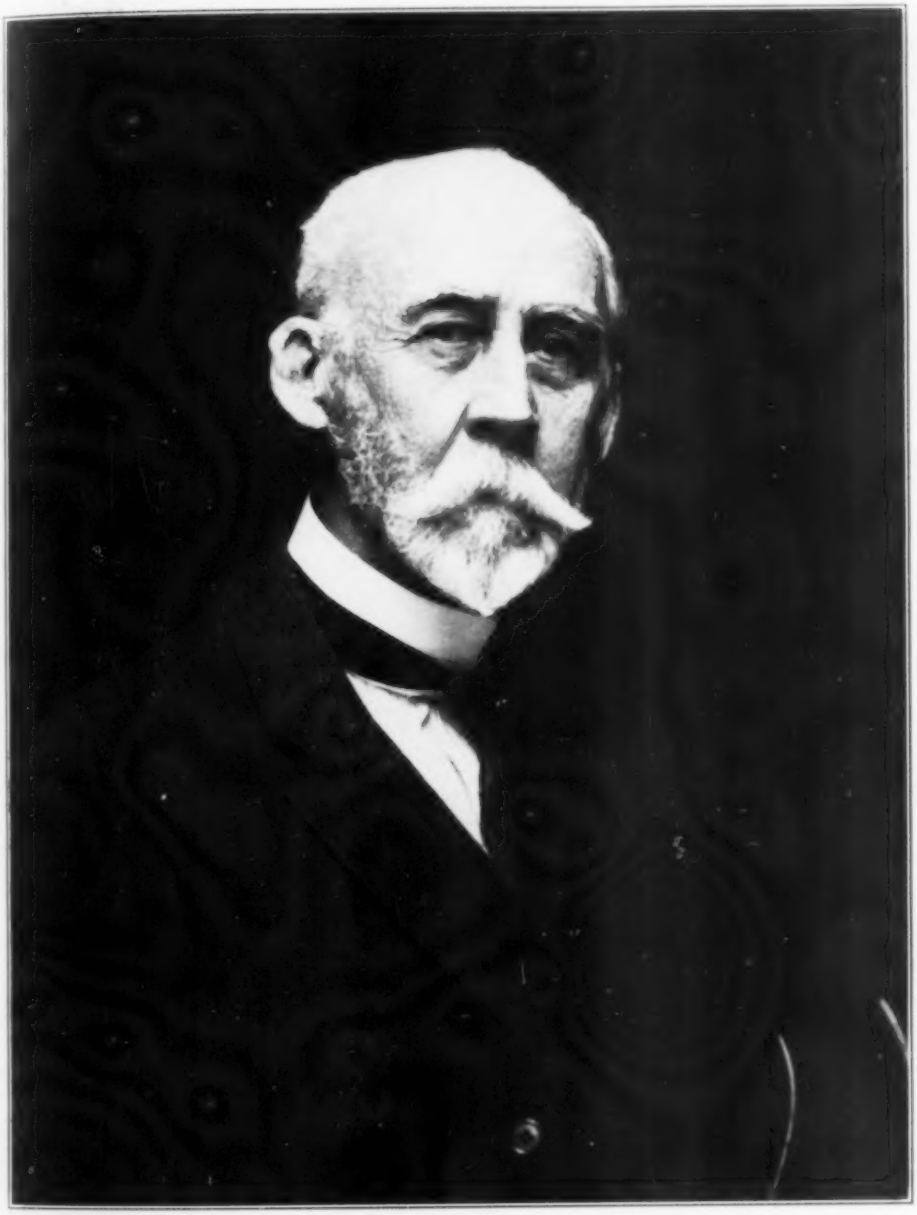
DINSMORE ALTER



—*E. L. Fowler*

THE ADLER PLANETARIUM

IN WHICH THE AMERICAN ASTRONOMICAL SOCIETY WILL HOLD SOME OF ITS SESSIONS.



WILLIAM HENRY HOLMES

THE DISTINGUISHED ANTHROPOLOGIST WHO DIED RECENTLY AT THE AGE OF EIGHTY-SIX YEARS.

CYRUS HALL McCORMICK

A. A. WEINMAN, SCULPTOR.

THE INVENTION OF THE REAPER

THE problem of the harvest is one of immense antiquity. Millenniums before the written records of the race appear, our ancestors seem to have hacked with sharpened flint at the life-giving grain. Almost by the time of Christ, man was engaged in fumbling efforts to develop for this purpose some type of power other than his own. The dawn of the era of industrial mastery accelerated the attempt. In the last quarter of the eighteenth century and in the first quarter of the nineteenth, more than fifty known trials of this nature are chronicled.

Upon a quiet farm in the lower valley of Virginia, in the summer of 1831, the first definite success was realized. The inventor of the machine, later to be perfected into world-wide acceptance, was Cyrus Hall McCormick, then just twenty-two years old. The circumstances of his achievement add glory to what is probably the most significant aid to agricultural enterprise. Young McCormick did not live in a community marked by the contagion of industrial endeavor; he did not even know of the previous models brought out over the world. Stimulus had come, it is true, from his father's interest in fashioning machines, including experiments with a reaper. Chiefly, however, McCormick pondered in his own mind the difficulties and visualized in his own imagination the processes that might overcome them.

It could hardly be claimed that the reaper which was first publicly exhibited in a field near Steele's Tavern, a mile or two from McCormick's home in Rockbridge County, was totally successful. This model, in fact, was merely the first of a long series to be evolved by the inventor himself. Yet McCormick's earliest machine manifested a fusion of the elements which ultimately made effective the instrument of harvesting, notably the placing of motive power, the management of the grain to be cut, the type of the knife, the development and transmission of cutting power and the delivery of the grain after it had been cut. As Professor Hutchinson says, "In spite of the one hundred years of use and experiment since its invention, no alteration which materially changed any one of these parts has been found advisable."

The complete narrative of this contribution to the world's progress would include McCormick's patience in reshaping factors that proved inadequate; his prophetic vision of the future grain empire of America prompting his removal about a decade later to Chicago; his struggle with early competitors; his invasion of Europe, where he won recognition; his competence for developing a business which advertised and then made available the product he had designed; his generosity, turning into forms of helpfulness much of the wealth that rewarded him and making of him one of the chief philanthropists of his generation. His genius triumphed over a stubborn problem of the human environment, and his immense influence upon civilization was entirely beneficent. More than any other, probably, he liberated man from the thraldom of famine's threat; and he established a new sense of security for life.

FRANCIS PENDLETON GAINES,
President
WASHINGTON AND LEE UNIVERSITY

RADIO SYSTEM FOR LANDING AIRCRAFT DURING FOG[1]

I. Introduction

Tests and demonstrations carried on at the Newark Municipal Airport, Newark, N. J., during March and April, 1933, indicate the complete practicability of the Bureau of Standards radio landing system developed to assist aircraft in making safe landings under conditions of zero visibility. The work on this system was conducted by the Research Division, Aeronautics Branch, Department of Commerce, organized at the Bureau of Standards. The system employs three elements, a runway localizing beacon, marker beacons and a landing beam, to provide continuous and accurate information on the position of the aircraft in three dimensions as it approaches and reaches the instant of landing. Fig. 1 shows the ground transmitting equipment required and the relative location of this equipment on the Newark airport.

[1] Publication approved by the acting director of the Bureau of Standards of the U. S. Department of Commerce.

II. Runway Localizing Beacon

The runway localizing beacon gives indications of the directional position of the aircraft with respect to the airport and permits keeping the aircraft directed to and over the desired landing runway. A 200-watt transmitting set of the visual-beacon type, operating on 278 kilocycles and feeding small, multi-turn loop transmitting antennas, is employed. At the Newark airport the wind, under conditions of low visibility, is usually from the northeasterly quadrant. The runway beacon, accordingly, is located at the northeast end of the field. With the aid of a goniometer to swing the course anywhere between the two hangar lines, it is possible to accommodate practically all wind conditions during low visibility. On the aircraft, the same receiving set used by air transport operators for the reception of radio range-beacon signals and airways weather broadcasts is employed for receiving the runway beacon signals.

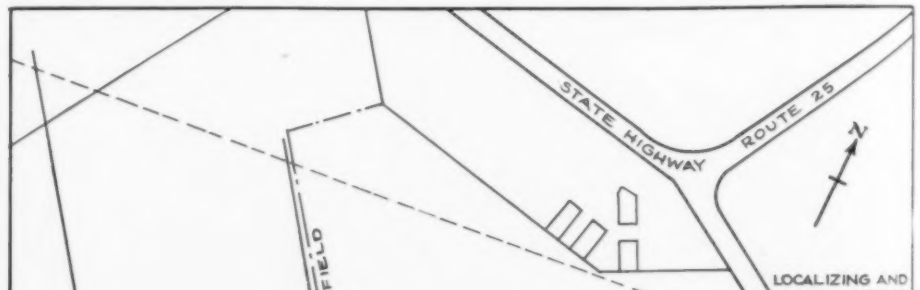


Fig. 1. Location of ground transmitting equipment for radio landing aids at Newark Municipal Airport.

FIG. 2. AIRPLANE USED IN HOODED LANDINGS SHOWING (A) BEACON RECEIVING ANTENNA AND (B) LANDING BEAM RECEIVING ANTENNA.

This set is augmented by a reed converter to convert the beacon signals to pointer-type course indications, given by the vertical pointer of the combined instrument (see Fig. 3), and also by an automatic volume control unit. A vertical index line across the face of the combined instrument represents the desired landing runway, while the position of the pointer corresponds to the relative position of the aircraft with respect to the runway.

III. Distance Indicator and Marker Beacons

Longitudinal position of the aircraft as it approaches the airport is given by the combination of a distance indicator on the aircraft with the aural signals received from two marker beacons. The distance indicator, operating from the beacon receiver, reads field intensity of the runway beacon and may be calibrated approximately in miles from the beacon (say, 0 to 5 miles). Absolute indication of the longitudinal position of the aircraft when near the airport is given by aural signals from two 5-watt (3,105 kilocycles) marker-beacon transmitters. These signals are received in the output of the high-frequency receiving set normally used for communication purposes. One signal, a high-pitched note, is heard, when within 2,000 feet of the southwest end of the airport. The second signal, a low-pitched note, is received when over the field boundary. The marker beacon transmitting antennas, 2 to 6 feet high, are stretched transversely across the line of flight of the aircraft, to provide signals for all orientations of the runway beacon course.

IV. Landing Beam

Vertical guidance is given by a horizontally polarized ultra-high-frequency landing beam (90,800 kilocycles). The landing-beam transmitter feeds a directive transmitting antenna array which gives the necessary directivity of beam in the vertical plane while spreading the beam out in the horizontal plane to afford service in the 40-degree sector. On the aircraft, a simple ultra-high-frequency receiver is used, fed by a transmission line from a horizontal half-wave receiving antenna which is located in the wing slightly ahead of the leading edge. (See Fig. 2.) The rectified output from this set operates the horizontal pointer of the combined instrument shown in Fig. 3. The receiver sensitivity is so adjusted that the line of constant received signal below the inclined

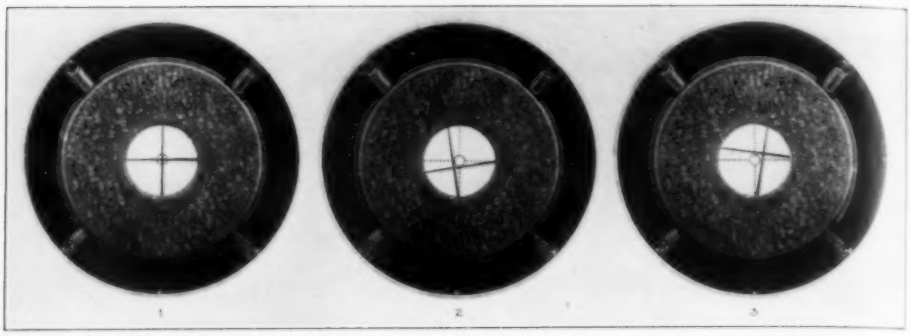


FIG. 3. TYPICAL COURSE INDICATIONS WITH COMBINED INSTRUMENT.

axis of the beam, corresponding to half-scale deflection of the horizontal pointer, marks out a landing path which is suitable for the aircraft and airport considered. The horizontal index line across the face of the combined instrument represents the half-scale deflection and corresponds to the proper landing path. The horizontal pointer represents the position of the aircraft relative to this path.

Referring to Fig. 3, consideration will show that the point of intersection of the two pointers represents the position of the aircraft relative to the desired landing runway and the proper landing path. Three typical course indications are given. Deviations from both courses may be corrected simultaneously. By keeping the pointers crossed over the small circle on the instrument face, a suitable spatial landing path is followed down to the point of landing. The system requires a minimum of manipulation on the part of the pilot. Once the beacon receiver is tuned to the frequency of the runway beacon, no further adjustments of tuning or sensitivity of any of the receiving equipment is required.

V. PERFORMANCE TESTS

The demonstrations at Newark were preceded by an extensive series of tests at College Park, Maryland, where the practicability of the system was studied by means of flights and landings in an airplane equipped with a canvas hood over the pilot's cockpit. Over a hundred hooded landings were made during these tests. A check pilot was used in the front cockpit to take care of faulty landings or other emergencies. The installation at Newark was then made to determine the operation of the system under the conditions obtaining at a commercial airport. During the two months of tests, besides making a large number of hooded landings, it was possible to fly at all times when the scheduled air mail and passenger airplanes were on the ground because of fog. The operation of the system was demonstrated in the air to many engineers and officials as well as to nearly one hundred air transport pilots.

Perhaps the most striking demonstration consisted of a completely blind flight from College Park, Maryland, to the Newark Airport on March 20. Flying at 3,000 feet altitude, in dense fog, the Washington and New Brunswick radio range-beacons were followed up to the point of tuning in the runway beacon at Newark. The landing beam course was picked up at 3,000 feet altitude at a distance of 7 miles from the airport. Except for an instant over Baltimore, no sight of the ground or sky was had from the time of leaving College Park until receiving the first marker beacon signal at Newark. The aircraft was then only 100 feet above ground.

H. DIAMOND
NATIONAL BUREAU OF STANDARDS